

KEYNOTE PRESENTATION

ARCTIC PALAEOCEANOGRAPHY: PAST, PRESENT, AND FUTURE

Dennis A. Darby

Dept. of Ocean, Earth, & Atmospheric Sciences, Old Dominion University, Norfolk, VA 23529,
USA

While the early oceanographic work in the Arctic Ocean dates to expeditions in the 19th century, palaeoceanographic research work did not begin until the 1920's with the Russian ship expeditions and, starting from the late 40's with the "North Pole" (NP) ice stations and short cores collected from these (Belov and Lapina, 1961). These early works were the first to describe the cyclicity of Arctic sediments and interpret the lithological and microfaunal changes. Unfortunately they were never published in widely circulated journals and have remained ignored outside Russia. The coring efforts on ice-island T-3 in the 60's was the initial effort by the US followed by several ice stations including the Canadian CESAR expedition in 1983. These provided a wealth of findings that led to the earlier stratigraphy of the central Arctic (Clark et al., 1980). While the European effort in the Arctic was oceanographic in nature during the early half of the 20th century, palaeoceanographic work with sediment cores dates mostly from the 80's to today. This began with the Swedish YMER expedition to the Arctic near Svalbard in 1980 and continues to this day with multiple expeditions by Polarstern and Oden. The US joined this trend in the 1990's with the polar class icebreakers and in 2002 with the USCGC Healy, the first US icebreaker designed for Arctic research. Key to these expeditions was the development of the first realistic bathymetric charts (Perry and Fleming, 1986).

A non-scientific survey of some of the leading Arctic palaeoceanographers lists the top discoveries of the last couple decades as the IODP Arctic Coring Expedition (ACEX) in 2004 (Bachman et al., 2004) and the discovery of grounded ice masses up to 1 km deep on the Lomonosov Ridge dating to OIS 6 and at 400-1000 m on the Chukchi Borderland dating to several events including possibly OIS 2 (Polyak et al., 2001, 2007; Jakobsson et al., 2005). ACEX was the first real core material from continuous sections of the Cenozoic Arctic and revealed a warm, freshwater surface layer during the Eocene with many surprises, such as apparent ice-rafted detritus (IRD) as early as about 45 Ma. The ice groundings provide a radical view of Arctic ice sheet dynamics and the possible growth of ice shelves at these times. Another important discovery was that the Arctic is not as poor a recorder of the Pleistocene as was thought. Sedimentation rates in some areas such as the central Lomonosov Ridge appear to be nearly an order of magnitude higher than earlier estimates (Clark et al., 1980; Backman et al., 2004). It's not surprising that both the ACEX drilling and the discovery of ice groundings resulted from technological advances that allowed access to the Arctic (icebreaker capabilities and availability) for coring, bathymetric, and seismic surveying. Several other advances deal with the application of new techniques to the Arctic sediments such as Fe grain chemical fingerprinting for provenance as well as several other proxies now in use or under study. Several examples of some of the findings from the last decade will provide a better picture of our current understanding of palaeoceanography in this ocean and what might lie ahead.

There are several unresolved issues highlighted by this survey. One of the most pressing is the development of a viable chronostratigraphy for the Arctic. Several approaches are under investigation but this essential tool still eludes us. Because the ACEX core contains a huge hiatus from 18 to 44 Ma, and ended in the latest Cretaceous, there is an obvious need for more drilling in the Arctic. While high resolution records have been shown to exist at the Arctic margins (Darby et al., 2005), finding such records in the central Arctic in several locations will be essential to piece together a detailed palaeoclimate record so badly needed to guide and constrain model projections of future climate change in the Arctic. While recent icebreaker coring expeditions have demonstrated the ability to core nearly anywhere in the Arctic, the necessary seismic data

to find drift deposits and site locations for drilling remains a problem dictated by ice conditions. The progressing packice melt is working in our favor here, but to resolve these other problems will require research into new proxies and dating techniques because unlike other oceans, the Arctic sediments are virtually barren below 650 Ka and standard stable isotope chronostratigraphy does not work (Spielhagen et al., 1997). Funding agencies have to be encouraged to fund this research, which usually involves a greater risk of failure than what they like to fund.

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KEYNOTE PRESENTATION

MODELLING GREENLAND ICE SHEET SENSITIVITY TO CLIMATE CHANGE

Shawn Marshall

Department of Geography, University of Calgary, Calgary, AB T2N 1N4, Canada

Even seasoned glaciologists have been caught off balance by the extent of glacier and ice sheet response to recent climate change. Rates of ice loss and cryosphere-driven sea level rise have doubled over the last decade, driven by increased melting, thinning at marine margins, and accelerated discharge from outlet glaciers in parts of Greenland and West Antarctica. These observations call for a close evaluation of the skill and capacity of current glaciological and glacier-climate models, but they also beg a better understanding of how the Greenland and Antarctic Ice Sheets have changed in the past. I discuss several processes that models need to describe in order to capture the mechanisms of rapid glacier- and ice-sheet response to oceanic and atmospheric forcing. Many of these processes are a challenge to introduce in models because of poorly-understood or non-deterministic physics, scale issues, and the complexity of the coupled models that are required. However, the compelling observational record and the importance of quantifying future sea level rise are driving a focused effort and significant progress can be expected in modelling efforts. I discuss this in light of mixed evidence about the fate of the Greenland Ice Sheet during the last interglacial period.

LATE QUATERNARY GLACIAL AND MARINE ENVIRONMENTAL CHANGE AT FORLANDSUNDET, SVALBARD

Helena Alexanderson^{1,2}, Jon Landvik¹ and Heidi Ryen¹

¹Department of Plant and Environmental Sciences, Norwegian University of Life Sciences, Norway

²Nordic Laboratory for Luminescence Dating, Risø National Laboratory, Aarhus University, Denmark

The ~30 m high coastal cliffs on the south-western part of Brøggerhalvøya reveal a long story of glacial activity and marine environmental change on Svalbard, an area which is strategically located to detect climate change through time in the Arctic. Five main lithofacies associations, which represent different depositional environments, occur repetitively in the sedimentary succession: silty subglacial till, glaciomarine silt and clay, sandy marine deposits, dipping beds of gravel and boulders likely to represent subaqueous fans, and beach gravel. The changes in facies thus record roughly cyclic development on the order of thousands of years, and reflect sustained changes in sea level interrupted by glacial advance and retreat. The environmental change during a cycle includes sub-glacial, glaciomarine, followed by marine and eventually beach deposition as the relative sea level fell due to isostatic rebound. Each cycle is not complete and variations in individual units together with the occurrence of minor facies associations give more detail and complexity to the site. At least four periods of ice cover are indicated by tills and striated bedrock, and the depositional direction of one of the gravelly-bouldery units may also suggest an ice sheet in the Forlandsundet.

The ages of the different units will be determined by optically stimulated luminescence, electron spin resonance and radiocarbon dating. Previous investigations by Miller et al. (1989) suggest that the succession ranges in age from the Holocene to the Saalian.

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INDICATIONS OF EXTREME LATE PLEISTOCENE ARIDITY IN NORTHEASTERN EUROPE

Valery Astakhov¹ and John Inge Svendsen²

¹Geological Faculty, St. Petersburg University, Russia

²Department of Earth Sciences, University of Bergen, Norway

The Pleistocene of the northeast of the Russian Plain and environs has traditionally been described within the palaeogeographical framework implying abundant moisture for alternating glacial and marine events. The Russian-Norwegian studies in the Pechora Basin and Polar Urals of 1993-2005 revealed many features that can only be explained by vigorous wind action in an arid environments, especially during the second half of the Late Pleistocene. First of all, it is the structure of the discontinuous sedimentary mantle which occurs upon all topographic elements, except floodplains (Mangerud et al., 1999; Astakhov et al., 2007). It consists of four genetic types of sediment. One of them, the soft dark diamicton, observable mostly in the Uralian foothills, is related to gravity flow of water-soaked soliflucted soils on perennially frozen slopes. This periglacial colluvium, more common for the beginning of the last glacial cycle or for the Holocene, may in places make thin wisps also in the Late Weichselian sequences.

Other sediments of the surficial mantle are largely windblown. These are i) dune sands with long diagonal bedding, ii) laminated coversand and iii) loess-like silts (Astakhov et al., 2007). In places they appear intercalated, as at the Byzovaya Palaeolithic site (Heggen et al., 2000; Mangerud et al., 2002). Spatially they replace each other, ancient dunes being more frequent north of the Middle Weichselian glaciation limit along the Barents Sea coast, on the arctic stretch of the Pechora and along her eastern tributaries. Patches of laminated coversand are common beyond the Arctic Circle but south of it massive loess-like silt predominates. Previously most of the stratified surface sediments were mapped as lacustrine formations which in our opinion is erroneous because of i) their mantling occurrence, ii) long inclined beds or wavy lamination, iii) typical subaerial colours ranging from pale-yellow to pale-brown with intense rusty tint, iv) lack of aqueous sorting (no gravel and clay laminae or ripples), v) internal permafrost and pedogenic structures, vi) lack of associated beach facies. Principal sources of the windblown materials are interfluvial plateaus built of glaciofluvial or glaciotectionised marine sand and gravel, especially west of the Pechora in the Malozemelskaya Tundra and on the Timan Ridge. The plateaus are often adorned with isolated conical hillocks which exhibit armours of shattered pebbles and angular ventiform cobbles. We interpret these features as deflation residuals that may have provided sand and silt for the aeolian mantle farther east and south.

A number of OSL dates ranging from 33 to 13 ka (more frequent from 26 to 15 ka BP) has been obtained in the Pechora Basin from subaerial sands and silts devoid of macrofossils (Mangerud et al., 2002; Astakhov et al., 2007). The youngest mammoth bones from underneath the subaerial blanket of aeolian sediments are radiocarbon dated to 27 ka BP (Mangerud et al., 1999; Heggen, 2000). Few fluvial formations have been encountered within the time span 26-15 ka BP. With the exception of bones that have been collected at the Paleolithic site Pymva-Shor near the hot spring on river Adzva (Mangerud et al., 1999), no animal remains of this period are known from surficial sediments west of the Urals. Bones of mammoth fauna of this age have been found only in Siberia (Astakhov et al., 2004). These facts are another manifestation of extreme aridity of the main part of the MIS 2 interval in Arctic European Russia. Macrofauna reappears in final Pleistocene sediments dated to 14 to 12 ka ¹⁴C BP. The bones may reflect a weak humidification of the climate, which is also inferred from the increased fluvial activity, formation of thermokarst lakes and accumulation of solifluction sheets.

The above features indicate a perennially frozen, extremely dry environment with very meagre biota on the southeastern shores of the Barents Sea during the second half of the Late Pleistocene. The inferred polar desert is a natural continuation of the European sand belt

outlining the margin of the Late Weichselian ice sheet (Zeeberg, 1998). The arctic polar desert looks as a shadow of the adjacent Barents Ice Sheet that probably terminated in the Pechora Sea during MIS 2 (Gataullin et al., 2001). This ice sheet may have produced strong katabatic winds and unusually high aridity along the present Barents coast. Precipitation sufficient for supporting mammoth tundra-steppe was available only on the eastern leeward slope of the Polar Urals.

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PORE WATER CHEMISTRY INFERS ALTERATION OF SUBMARINE PERMAFROST SINCE THE LAST GLOBAL SEA-LEVEL RISE

Henning A. Bauch¹, Heidi Kassens², Hanno Meyer³, Yelena Polyakova⁴, Pavel Rekant⁵, Ekaterina Taldenkova⁴

¹Mainz Academy c/o IFM-GEOMAR, Kiel

²IFM-GEOMAR, Kie

³Alfred Wegener Institutue, Potsdam

⁴Moscow State University, Moscow

⁵VNIIOkeangeologia, St. Petersburg

There is general consensus now about a polar amplification of global warming. This fact is particularly true for the Arctic cryosphere which is very vulnerable to changes in temperature due to high complexity of various interacting environmental processes. Along the circum-arctic ocean periphery this cryosphere is widely comprised of terrestrial permafrost at present. However, during past Quaternary times this frozen landscape was repeatedly changed caused by fluctuations in both temperature and sea-level, which affected in particular the wide and shallow Siberian shelf seas. As western part of the Beringian landmass this region was subaerially exposed during the LGM when global sea level was lowest. During the ensuing deglacial time sea-level rose gradually changing a terrestrial permafrost landscape into a shallow, marine shelf environment. Various geochemical, micropalaeontological, palynological, and sedimentological data obtained from both conventional gravity cores and drill cores reveal the strong influence of this transformation process on the shelf environment. The sediments from just below the Holocene marine sediment package drilled on the outer shelf confirm the existence of permanently frozen, ice-bearing sediments with clear terrestrial affinity. However, the oxygen isotopes of the ice and the pore water as well as other geochemical evidence all indicate that the now frozen sediments were originally deposited in a brackish environment. At a later stage these sediments then became altered by re-freezing processes most likely induced from a large and colder permafrost body resting underneath. This assumption is further corroborated by high-resolution acoustic data, emphasizing the overall fragility of the natural state of submarine permafrost in the Arctic.

INFLUENCE OF DUST DEPOSITION AND PROGLACIAL LAKES ON THE SURFACE MASS BALANCE OF THE LARGE EURASIAN ICE SHEET DURING THE PEAK SAALIAN (140 k yrs BP)

Florence Colleoni^{1,2}, Gerhard Krinner¹, Martin Jakobsson², Vincent Peyaud¹, Catherine Ritz¹

¹LGGE CNRS, Grenoble, France

²Department of Geology and Geochemistry, Stockholm University, Stockholm, Sweden

Recent geologically-based reconstructions of the Eurasian ice sheet show that during the peak Saalian (140 kyrs BP) a huge ice sheet existed over Eurasia, while orbital parameters and greenhouse gases did not differ significantly from those at 21 kyrs BP. In this work we focus on the surface mass balance (SMB) of the Eurasian ice sheet during the peak Saalian and evaluate the impact of the presence of ice dammed lakes and dust deposition on the snow. Five simulations have been carried out using the LMDZ4 atmospheric model: REF0 (present-day), REF140 (Saalian ice sheet only), LAKES140 (lakes), DUST140 (dust), FULL140 (lakes and dust). Results show that SMB values are positive for REF140 and LAKES140 (lakes reduce melt values during summer) and negative for DUST140 and FULL140 (dust increase melt values due to positive feedback in albedo). In all the simulations, the largest accumulation rates are located along the south and west margins where precipitation rates are high due to the moisture fluxes from the Atlantic. In our ice reconstruction, the Eurasian ice sheet includes the Dniepr Lobe north of the Black Sea which exhibits a large negative SMB with high melt rates. Without this lobe, SMB values over the ice sheet remain positive for all the simulations except for DUST140. In the case of FULL140, lakes impact is enhanced by the presence of dust resulting in a large positive SMB. During the peak Saalian, the ice topography, internal regional factors and precipitation distribution contributed to the positive SMB values of the ice sheet and to its large southward extension.

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AN EPISODICALLY ICE-FREE GREENLAND DURING THE PLEISTOCENE

Anne de Vernal and Claude Hillaire-Marcel

GEOTOP-UQAM, CP 8888, succ. Centre-Ville, Montreal (Qc) H3C 3P8

Palynological analyses of cores collected at the Ocean Drilling Programme Site 646 off southwest Greenland in the northwest North Atlantic were performed with millennial-scale resolution for an interval spanning the last million years (i.e., isotopic stages 25 to 1). The samples yielded extremely variable palynological content, with regard to both marine palynomorphs (dinoflagellate cysts) and terrestrial palynomorphs (pollen grains and spores). In general, dinoflagellate cyst concentrations are high during interglacial stages (of the order of 10^4 cysts/cm³) and low during glacial stages ($< 10^3$ cysts/cm³), indicating large amplitude changes in productivity. The dinocyst data indicate relatively mild sea-surface conditions during interglacials with, however, assemblages differing from one to another, and yielding distinct oceanographical reconstructions. For example, maximum sea-surface temperatures seem to have characterized isotopic sub-stage 5e, but optimum sea-surface salinity occurred during stages 7c and 11. The palynological data also reveal high pollen and spore contents in sediments of many interglacial stages ($> 10^3$ /cm³), notably isotope stages 5e, 11 and 13. At Site 646, pollen content most probably relates to inputs from a relatively proximal terrestrial source that is necessarily the southern Greenland. Thus, pollen data suggest that Greenland was occupied by dense vegetation cover during parts of the Pleistocene. In particular, the dominance of *Picea* (spruce) and the occurrence of *Abies* (fir) in sediment of stage 11 suggest inputs from boreal forest type vegetation, thus ice-free conditions and a mild climate. This palynological record demonstrates large amplitude changes in the physiography (continental ice coverage), biogeography (vegetation on Greenland) and hydrography (temperature, salinity) over and off Greenland during the Pleistocene. They illustrate the extreme sensitivity of the central part of the North Atlantic with regard to climate and show that the regional response to climate warming has been significantly different from one interglacial to another. In particular, they reveal high instabilities of the Greenland Ice Cap during past interglacial stages. Aside from highlighting the Greenland ice-sheet vulnerability in a global change perspective, its significant reduction under the natural climate forcing of past warm interglacials raises the issue of the mechanisms responsible for its stability during the present interglacial.

ARE POLAR GLACIER MARGINS SUITABLE ANALOGUES FOR RECONSTRUCTIONS OF MID-LATITUDE PLEISTOCENE GLACIATIONS?

David J.A. Evans

Department of Geography, Durham University, South Road, Durham

A number of modern glacial landsystems analogues are identified from glacierized basins in arctic and alpine locations, from which moraine genesis can be inferred and then utilized in palaeoglaciological reconstructions. Potential seasonal signals can be identified in ancient push moraine sequences and can be clearly differentiated from former surging margins where glacetectonic thrust ridges have been constructed in association with other diagnostic landforms. More enigmatic are the wide morainic arcs of predominantly "hummocky terrain", which have traditionally been interpreted as the products of ice stagnation. Of particular significance is the explanation of linearity in "hummocky" end moraine sequences in a wide variety of settings ranging from cirque basins to the former margins of ice sheets in continental interiors. This has not always been explained by marginal pushing, dumping or glacetectonic disruption but rather as the preservation of former englacial debris concentrations after complete ice melt-out. As such these landforms qualify as "controlled moraines", where moraine form and pattern is controlled by englacial/supraglacial organization of debris concentrations. Such interpretations have significant implications for palaeoclimatic reconstructions in that glacier dynamics are inferred to be characterized by mass stagnation, even though the development of englacial structure is related to more dynamic behaviour such as englacial thrusting. Similarly, the impact of supraglacial reworking must be negligible in order to preserve moraine form. Only vertically or near vertically inclined debris concentrations may produce significant linear ridges. Assessment of the preservation potential of controlled moraine in the Quaternary landform record is accomplished through the analysis of the process-form relationships of recently deglaciated terrains in Iceland, Svalbard and Ellesmere and Baffin islands in the Canadian arctic, where glacier snouts display clear controlled moraine development and historical moraine systems have evolved from the downwasting ice. It is apparent that englacial structure may be represented in only crude form as low amplitude moraine belts that lack the intricate crenulations of marginal push moraines.

ASYMMETRY OF LOCAL GLACIERS EVEN IN THE ARCTIC; NEW RESULTS FROM SPITSBERGEN

Ian S. Evans

Department of Geography, Durham University

Local asymmetry of glaciation relates essentially to glacier balance on different slopes, modulated by local topographic factors. Topography permitting, it is expected that slope aspects with the most positive mass balance will generate more glaciers, and that these glaciers will have lower ELAs and mid-altitudes. A previous global survey (Evans and Cox 2005, Evans 2006) identified significant anomalies in a number of Arctic data sets, where the favoured aspect (direction, azimuth) in terms of numbers of glaciers differed from that with the lowest glaciers. These anomalies are investigated here, with special reference to the glaciers of Svalbard.

World Glacier Inventory (WGI) data show a mean aspect for 241 local glaciers in Svalbard of $013.6^{\circ} \pm 23.9$. However, the mid-altitudes are lowest for an aspect of $101.2^{\circ} \pm 29.4$, which is inconsistent. Tidewater glaciers have dominantly eastward aspects (Evans, 2007). As 488 glaciers are unclassified for type in the WGI data, the inconsistent results for glacier numbers and altitudes may be influenced by this incompleteness: also, data are given only for glaciers more than 1.5 km long and 1 km² in area, and are often incomplete for glaciers shorter than 5 km. Hence Svalbard glaciers appeared longer and less steep than those of any other region (Evans 2006).

As the missing smaller glaciers (slope, cirque and cirque-valley glaciers) are steeper and more influenced by slope mesoclimates, it is not surprising that some inconsistent results were obtained. Thus further data were generated for the aspect, altitude and length of 205 glaciers in the main area of local glaciation in Svalbard, Nordenskiöld Land around Longyearbyen and Grøndalen. Each glacier source (usually a cirque) and its tongue were treated as distinct units. All four mountain blocks have mean glacier source aspects of 356° to 018° , with an overall mean of $011^{\circ} \pm 8^{\circ}$. They also have lowest mid-altitudes at north to northeast, and lowest low altitudes predicted at 009° to 030° , with contrasts in lowest altitude averaging 157 m. Thus these consistent results show that local, land-terminating glaciers around 78° N are affected more by north-south radiation receipt contrasts than by wind effects.

Returning to the WGI data, analysis by region, of glaciers of all types, shows north-northeast aspects for southern, central (Nordenskiöld Land) and northwest Spitsbergen, but not for northeast Spitsbergen or the eastern islands, dominated by icecap glaciation.

Other data sets show north-northeast as a strongly favoured aspect on Disko I, Greenland, at 70° N, and a 288 m north-south contrast in ELAs on Beerenberg, Jan Mayen I., at 71° N. It is concluded that, although weaker than in mid-latitudes, north-south contrasts due to mesoclimates are significant even in Arctic glaciers.

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LONGTERM 2007 IN NORTHERNMOST GREENLAND – RETURN TO THE REAL ARCTIC

Svend Funder and Kurt H. Kjær

Natural History Museum, University of Copenhagen, Oster Voldgade 5-7, DK-1350 Copenhagen

The field work this summer was a continuation of the work in 2006, this year with 11 persons in the field for 41 days. The work was concentrated on the coastal plain along the Arctic Ocean coasts from Kap Morris Jesup (83°30'N) in the north to Herlufsholm Strand (82°30'N) in the south. An archaeo-geological programme in the inland had to be given up because the target area could not be reached. As in 2006, the aim of the project was to study the long-term records and interaction between glacier dynamics and sea-ice along the Arctic Ocean coasts. In addition to this, the archaeo-geological programme throws light on the life conditions and sensitivity to environmental change for the early immigrants to this extreme area. Besides general mapping of landforms and logging of sections we have employed exposure dating, lake coring, dendrochronology of driftwood, DNA analyses, and – of course – C14 dating to obtain the record. The preliminary results from this summer, together with data from the previous, indicate: 1) During LGM the coastal plain was covered by an ice-shelf fan, fed by outlets from the Inland Ice further to the west. Ice-shelf fans are not known from other parts of Greenland, and may be conditioned by thick stagnant sea ice. 2) The ice-shelf fan began to break up already in the Late Weichselian, and before the transition to the Holocene the plain was cleared of ice and, up to c. 45 m asl, transgressed by the sea. 3) After this, probably in the Early Holocene, there was a resurgence of local glaciers through all major coast-facing valleys. 4) During the Holocene climatic optimum, at c. 8-7.5 ka, sea-ice in the Arctic Ocean may have diminished to “greenhouse conditions”, and wave generated beach ridges formed on exposed coastlines. 5) Driftwood from Canada and Siberia increased in frequency after c. 6.5 ka, possibly indicating strong winds sweeping away the fast ice and exposing the prominent parts to drifting pack. 6) One lake core, obtained in 2006, goes back to 10-11 ka, while another, reaching back to c. 3 ka has shown that the air up here – contrary to other high Arctic areas - is pristine, and almost devoid of industrial pollution.

The expedition was marred by a number of unforeseen incidents that caused constant change of plans and decreasing ambitions. Some were logistic - the expected helicopter support was cancelled, which forced us, as in 2006, to change to Twin Otter support with its restricted possibilities for landing. But the most serious problems were caused by the weather. In the early part of the season excessive heat caused ice dams to break and the inundation of a camp and its landing strip. In the late season this changed to an almost continuous series of Polar lows sweeping over the coast, ruining tents and burying camps in snow - transforming the inhabitants into hibernating pupas in their sleeping bags - dreaming of the greenhouse effect to come.

PLIOCENE-QUATERNARY SEDIMENTS OF CHUKCHI SEA SHELF

Evgeny Gusev¹, Pavel Rekant¹, Victor Popov², Alexander Iosifidi², Elena Polyakova⁴, Lyudmila Derevyanko³, Nadezhda Anikina³, Ivan Litvinenko¹, Tatiana Klyuvitkina⁴, Alexey Usov¹

¹VNIOkeangeologia, St. Petersburg,

²VNIGRI, St. Petersburg

³“Mireco”, Syktyvkar

⁴Moscow State University

VNIOkeangeologia carried out a fieldwork in Chukchi Sea in 2006 on board the “Shuya” vessel under the State program of “third generation” geological mapping scaled 1:1000000. The methodology included standard kit of techniques, seismoacoustic profiling, sonar survey, sampling by grab and piston corers, and shallow drill coring that used an original technology developed in Donetsk Technical University, Ukraine [Kalinichenko *et al.*, 2001]. Importantly, three boreholes were drilled, near Schmidt Cape, 5.5 m deep, at the southern edge of Wrangel Island (12 m), and in the southern part of Chukchi Sea, down to 3.5 m into the sediments.

The latter hole due to its negligible depth did not heave the batch of Holocene deposits. Two others cut three seismostratigraphic units, Upper Pleistocene – Holocene, Eopleistocene (?), and Pliocene. A distinct unconformity is observed between the Eopleistocene (?), and Pliocene seismostratigraphic units, and the Eopleistocene (?) deposits lie on an eroded top of the Pliocene rocks. Upper Pleistocene – Holocene and Eopleistocene (?) seismostratigraphic units are represented by fine marine silts and clays with mollusk shells and rare small pebbles. The Pliocene complex is built of sand and sandy silt with pebble and gravel and numerous fragments of burnt lumber.

46 samples from the first, and 114, from the second, boreholes were selected for paleomagnetic study. In the samples from the upper parts of both sections a component of direct polarity is identified. We refer this part of the sequence to the Brunnes epoch. A reverse magnetization zone begins from the 3 m depth in the first, and 7 m, in the second boreholes. This likely corresponds to the Matuyama orthozone. In the upper part of this orthozone, some non-uniformities are observed in both sections: in section 1, a brief interval of frequent alternation of polarity is observed, and in section 2, a short zone of direct magnetization. Perhaps this can be related to a part of Jaramillo microzone of the Global Magnetic-Stratigraphic Scale.

Spore and pollen spectra from both boreholes show a twofold structure of the upper part of the sediment cover of the Chukchi Sea shelf. The relatively lower part of the sequence is believed to have formed in a warm environment in Late Pliocene and Eopleistocene (?), when the deposition area was occupied by pine-and-birch woods with Siberian pine, fur, alder, willow, hazel, and deciduous species. Moisture-loving species typical for swamps dominated among the herbs, but wood-free areas were generally rare. The climate was warmer than now. Such spore-and-pollen complex could be compared with those of Pestsovskaya Formation of Chukotka Peninsula [Petrov, 1966] and Kolvinskaya Formation of the Timan-Urals region [Zarkhidze, 1992]. The upper part of the sequence was formed in Late Pleistocene and the Holocene when a forest-tundra and tundra vegetation occupied the considered territory.

The microfauna analysis of samples showed that foraminifers were absent in the lower parts of the sections of both boreholes: below 3 m in the first, and below 7 m, in second borehole. Thus, a continental or subcontinental genesis was proposed for the lower sediment batches, i.e. for the Pliocene unit and the bottom part of Eopleistocene (?) unit. Microfauna samples from the rest of Eopleistocene (?) deposits show from 6 to 11 species, cold-water Nonionidae, Retroelphidium, and Cribroelphidium definitely prevailing. Numerous agglutinated forms and underdeveloped shells are found. Such species as *Elphidium orizonense*, *Retroelphidium selseyense*,

Sigmomorphina sp., *Quinqueloculina longa* indicative of marginal layers between Pliocene and Eopleistocene at the north of Chukotka Peninsula occur in the said samples. The samples from the Upper Pleistocene – Holocene deposits include from 15 to 34 species. Arctic species predominate, *Guttulina lactea* (Walk. Et Jacob), *Buccella troizkyi* Gud., *Cribronion obscurus* Gud., *Haynesina orbicularis* (Brady) as well as some others – Arctic-Boreal (*Buccella frigida* (Cushman.), *Cribronion incertus* (Will.), *Nonionella auricular* (H.-A.-et Earl.), *Retroelphidium atlanticum* Gud. And so forth). Boreal-Arctic and boreal species are notably more scarce.

The diatoms were found only in the upper part of the borehole 2 section above 5.5 m. These are represented mainly by marine species typical for modern Arctic seas or by redeposited shells of extinct Neogene species. Diatoms are not abundant in Eopleistocene (?) deposits, just accidental shells of marine cold-water Arctic-Boreal species are reported – *Thalassiosira gravida* (spores), *T. nordenskiöldii*, *Bacterosira bathyomphala* and some others, and also some relatively warm-water species (*Coscinodiscus radiatus*, *Thalassiosira anguste-lineata*, etc.). This is common for marine Eopleistocene diatom associations of Enmakai Formation of Northern Chukotka. The amount of diatoms rapidly increases in the Upper Pleistocene and Holocene sediments cut by the boreholes. Dominant are the species that commonly occur in modern Arctic plankton (*Thalassiosira gravida*+*T. antarctica*, *T. nordenskiöldii*, *T. hyperborea* and others), as well as ice-hosted marine diatoms (*Fossula arctica*, *Fragilariopsis oceanica*, *Attheya septentrionalis* and so on), which naturally evidence for an ice coverage of Arctic seas.

The distribution of organic carbon and carbonate carbon in the sedimentary sequence as described in Borehole 2 correlates well with the paleomagnetism, microfauna, and spore-pollen data. Thus, the organic carbon and carbonate carbon rates within the 0-316 cm interval correspond to background values for modern terrigenous Holocene deposits of the Arctic shelf and are, respectively, 0.06% and 0.72%. Down the section, a natural diagenetic loss of carbon takes place from 0.95% to 0.51%.

In the 450-540 cm interval, with the generally constant carbonate level, the organic carbon drastically increases up to 1.82% that can be explained by change of marine environment to continental one and related increase of income of humus sedimentary material. Another rapid increase of the organic carbon is observed in the 613-623 cm interval and can be interpreted by shallow-water continental sedimentation environment that is confirmed by ostracoda abundance in the said interval.

Further down (>8 m), the organic carbon soars up again (1-3%) and so does the carbonate carbon (0.14-0.33%). We believe this documents a change of facies that could be related to the Holocene climatic optimum combined with sedimentation in continental shallow basins with considerable income of humus organics.

Our data generally support the stratigraphic models of Neogene–Quaternary sedimentary cover suggested for adjacent areas of Chukotka Peninsula [Petrov, 1966], Wrangel Island [Gualtieri et al., 2003], and East-Siberian Sea shelf [Puminov, 1981]. Still, the sections of Pliocene-Quaternary deposits dated based on paleomagnetic and biostratigraphic data were obtained for the first time at the Chukchi Sea shelf.

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ABRUPT CLIMATE CHANGES REFLECTED IN LATE GLACIAL TO HOLOCENE MARINE PROXY RECORDS FROM THE EURO-ARCTIC MARGIN

Morten Hald¹, Katrine Husum¹, Juho Junttila¹, Sergei Korsun², Kari-Lise Rørvik¹, Lindsay Wilson¹, Steffen Aagaard Sørensen¹ and Kasia Zamelczyk¹

¹Department of Geology, University of Tromsø, Dramsveien 201, N-9037 Tromsø, Norway

²Shirshov Institute of Oceanology, Nakhimovsky Prospect 36, Moscow 117995

Climate modelling experiments predict a global warming of about 3 °C during the next century, and that warming of the high northern latitudes may be as much as twice the global mean depending on the future emissions of greenhouse gases. To improve the predictions of future climates, particularly on regional scales, a better understanding of the natural climate changes based on archives extending back beyond the instrumental records is needed. This study contributes to this goal by investigating the Late Glacial and Holocene climate changes in the northern North Atlantic. Influx of Atlantic Water to this area contributes to the present mild climate of north-western Europe because large amounts of heat are released into the atmosphere during winter time when this water cools before sinking and contributing to the North Atlantic Deep Water (NADW). This system of currents is part of the North Atlantic thermohaline circulation (THC). Detailed studies of paleoclimatic proxy records extracted from marine sediment cores reveal that influx of Atlantic Water and the THC have varied significantly on timescales from 10 to 1000 years since the last glacial maximum (LGM) to the present. In this study we will present new results from LGM of the Vestfjorden Ice Stream, the deglaciation of the southern Barents Sea and the West Spitsbergen margin, and the Holocene climatic evolution of the Norwegian-Barents Sea- Svalbard margins.

RECENT CHANGES IN GEOCHEMICAL AND BIOGENIC FLUXES IN THE FRAM STRAIT AREA

Anne de Vernal¹, Claude Hillaire-Marcel¹, Sophie Bonnet¹ and Jean Carignan²

¹GEOTOP-UQAM, Canada

²CRPG-Nancy, France

Grain-size, palynological, bulk-sediment isotope and elemental analyses were performed in surface samples and two multi-cores from the 2006 Jan Mayen expedition in the Fram Strait area. The two box-cores were raised from both extremities of a transect from ~ 7°E to 12°W at ~ 75°N. At these sites, a contrasting stable lead isotope signature suggests lead supplies from NW European/Variscan sources whereas, west and east of the transect, lead from surface sediment illustrate a stronger influence of Greenland/Scandinavia and/or Mid-Atlantic volcanism. Near core-tops, the increase in lead concentration responds to post second World-War anthropogenic contamination, with some decrease near sediment surface following the Environmental Protection Agency 1973 ban on the use of lead in gasoline. Surprisingly, both core sites indicate a similar sources of contaminating lead carrying a strong North American and lesser European lead signature ($^{206}\text{Pb}/^{204}\text{Pb} \sim 18.11$; $^{206}\text{Pb}/^{207}\text{Pb} \sim 1.161$), but with an inventory about 10 fold higher at the easternmost site. At this site, characterized by a sedimentation rate of about 20 cm/ka, based on a few ^{14}C -ages, deep mixing is indicated by ^{210}Pb -excess activities down to ~ 8.5 cm sub-bottom. Records, from this core might thus be smoothed with a near Gaussian-shaped window of about 500 years. Coarse fraction peaks in the sediment suggest episodes with high ice-rafting deposition. Palynological analyses in surface sediment samples yielded assemblages showing east to west gradient. In eastern and central Fram Strait marked by the northward penetration of North Atlantic waters, they are characterised by high concentration of the order of 10^3 - 10^4 cysts.g⁻¹ and by a relatively high number of species including *Spiniferites elongatus* and *S. ramosus*, in addition to *Operculodinium centrocarpum*, *Islandinium minutum*, *Brigantedinium* spp., *Nematosphaeropsis labyrinthus*, *Impagidinium pallidum* and *Pentapharsodinium dalei*. In western Fram Strait and off the Greenland margin, concentrations are lower by one or two orders of magnitude and the species diversity decreases, with *O. centrocarpum* and *I. minutum* being dominant. Palynological analysis was performed at one centimetre interval in core JM-06-04 and provides an insight into the history of surface water mass during the last 2300 years. Dinocyst assemblages show notable variation in taxa occurrence, with *Spiniferites mirabilis*, *Selenopemphix quanta* and *Impagidinium sphaeridium* being recorded in the lower part of the record (before 600 BP) that can be associated to the medieval warm period. Dinocyst assemblages were used to reconstruct changes in sea-surface condition. They suggests a general trend of cooling since 1300 AD until the pre-industrial interval, which is marked by temperature decrease of more than 4°C (both in winter and summer), slight decrease in salinity and significant increase in sea-ice cover. Superimposed to the general trend, there seems to be sub-millennial variations. In the overall series, the interval around 1300 AD was apparently characterized by ice-free conditions and might constitute the most recent analogue of regional climate as warm as modern.

TESTING PEAT HUMIFICATION AS A CLIMATE RECORD: ASSOCIATIONS BETWEEN A NEWFOUNDLAND BOG AND GISP2 EXAMINED USING A MULTIPLE BANDWIDTH CORRELATION TECHNIQUE

P.D.M. Hughes¹ and N.A. Odoni²

¹School of Geography, University of Southampton, Highfield, Southampton, Hants., SO17 1BJ, UK.

²Department of Geography, Durham University, Science Laboratories, South Road, DURHAM, DH1 3LE, U.K.

The rôle of ombrotrophic peat-based proxies in aiding reconstruction of Holocene palaeoclimates is now well established, and there is widespread use internationally of such proxies, including plant macrofossils, testate amoebae, and degree of peat humification. More specifically, each proxy type, subject to certain assumptions, is regarded as an indicator of change in bog surface wetness (BSW), which has been related to the prevailing atmospheric moisture balance (precipitation – evaporation) at the time of peat deposition. In this respect, recent work has suggested that peat humification may be too indirect in its relationship with climate to be useful as a proxy climate indicator. In this paper, we present results which appear to challenge this hypothesis. A peat humification record, derived from a bog in northern Newfoundland and extending over 8,000 years, is compared with wider regional climate variations inferred from GISP2. Visual examination suggests periods of association between the records, and this is further tested by application of a multiple bandwidth correlation technique to the data, covering the period from c. 5,500 B.P. to the present. Although the correlation method takes into account possible dating errors, results show clearly that there are long periods (10^2 - 10^3 years) of significant positive correlation (c. 0.4) between the records, with sudden switches to similarly sustained periods of negative correlation. The amplitude and temporal persistence of correlations are found to vary with bandwidth in a consistent manner. These findings suggest strongly that there are mechanisms which enable environmental conditions over the bog and the ice cap to stay positively correlated with each other for long periods. The results also suggest the operation of processes which force the two systems out of synchronicity, although this latter aspect of the correlations may be explicable through dating errors. The multiple bandwidth correlation technique has potential for application to a wide range of Holocene and Quaternary time series.

LATE QUATERNARY GLACIAL HISTORY OF SVALBARD – PROBLEMS AND POTENTIALS

Ólafur Ingólfsson

Department of Earth Sciences, University of Iceland, Askja 232, Is-101 Reykjavík, Iceland

Our current perception of the Late Quaternary glacial history of Svalbard is highly influenced by the results of the PONAM program in the early 1990's. Two key publications, Mangerud *et al.* (1998) and Landvik *et al.* (1998) critically evaluated the available data and presented syntheses on the Late Quaternary glacial history and Last Glacial Maximum (LGM) and post-LGM deglaciation, respectively. The QUEEN synthesis for the development of the Eurasian ice sheet (Svendsen *et al.* 2004) ties to the PONAM paradigm and suggests remarkable similarities between the western and eastern flanks of the Svalbard-Barents Sea-Kara Sea ice sheet through the last interglacial-glacial cycle. There are, however, reasons to believe that the event stratigraphy and chronology of glacial events on western Svalbard need to be critically reinvestigated and perhaps radically revised:

- The status of an Early Weichselian (110 ka BP) glacial expansion on the west coast of Svalbard is unclear, as some of the stratigraphic evidence for it is being reinterpreted.
- There are fundamentally contradicting data on the stratigraphy of one of the key sections, Kapp Ekholm in Billefjorden, central western Spitsbergen (Mangerud *et al.* 1998; Forman 1999).
- Recent terrestrial and marine data may suggest a more dynamic behavior of the Svalbard-Barents Sea ice sheet along its western perimeter than previously perceived (Landvik *et al.* 2005; Ottesen *et al.* 2005).
- There are still contradicting interpretations of the glacial record of Kongsøya, central-northern Barents Sea, that need to be resolved for a better understanding of the repeated Late Quaternary build-up and vanishing of the Svalbard-Barents Sea ice sheet (Ingólfsson *et al.* 1995; Mangerud *et al.* 1998).

This paper will outline research strategies and methods necessary to deal with those exiting aspects.

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FOSSIL FIND ON SVALBARD SHEDS LIGHT ON THE NATURAL HISTORY OF THE POLAR BEAR (*URSUS MARITIMUS*)

Ólafur Ingólfsson¹ and Øystein Wiig²

¹University of Iceland, Department of Earth Sciences, Askja 232, Is-101 Reykjavik, Iceland

²Natural History Museum, University of Oslo, P.O. Box 1172 Blindern, N-0318 Oslo, Norway.

During recent fieldwork on Svalbard a well preserved subfossil left ramus of a polar bear (*Ursus maritimus*) mandible was discovered. On the basis of osteological studies of the mandible we speculate that it is from a fully grown female. A ¹⁴C age determination shows that it is older than 45 ka (kilo-years), and an OSL age determination and the stratigraphic position of the bone makes us suggests that it is 130-110 ka. This makes the find the oldest fossil remain of a polar bear ever discovered. The combined evidence of the fossil record and molecular (mtDNA) studies of evolutionary relationships among polar and brown bears suggest that polar bears developed from brown bears >200 ka BP. If true, the present interglacial is at least the second such the species has to endure.

BARENTS SEA ENVIRONMENTS: FROM THE LATE WEICHSELIAN EXTREME TO PRESENT

E.V. Ivanova¹, N.O. Chistyakova.¹, B. Risebrobakken.², and T.A Khusid¹

¹Shirshov Institute of Oceanology Russian Academy of Sciences, Moscow, Russia

²Bjerknes Centre for Climate Research University of Bergen, Bergen, Norway

Foraminiferal assemblages and stable isotope variations have been compared in several sediment cores along N-S and W-E transects across the Barents Sea to investigate the spatiotemporal paleoenvironmental changes. The age-models based on the isotope records and AMS-14C dates were developed within this and previous (Duplessy et al., 2001; 2005) studies. The postglacial (pre-Holocene) sediments are generally barren or contain very scarce benthic foraminifers, e.g. in the Franz Victoria and Persey troughs, and in the Central Deep, because of severe environmental conditions during the ice sheet decay and melting. However, in a few cases foraminifers are represented by so-called atlantic species which indicate unstable subsurface Atlantic water penetration into the sea. The most abundant and diverse assemblages are found in the SW part of the basin. This benthic fauna is dominated by typical arctic species and *Melonis barleeanus* whereas planktic foraminifers are represented by the most cold-water species *Neogloboquadrina pachyderma* sin. as a result of very low sea-surface temperatures. The Pleistocene/ Holocene boundary is marked by a dramatic increase in foraminiferal abundance and changes in the assemblages. In the SW, the atlantic species become more abundant than the arctic ones. Planktic assemblages also demonstrate pronounced changes with the maximum content of boreal species in the Early Holocene. In the east, a relatively high proportion of *Nonion labradoricum* in benthic assemblages of core ASV 1310 from the Western Novaya Zemlya Trough may indicate an increase in bioproductivity. This allows us to speculate about a nearby position of the Novaya Zemlya ice sheet or, alternatively, of the Polar Front shift to the east ~ 9.3 - 7.7 cal ka BP. Occurrence of *Cassidulina teretis* in the same interval supports an eastward shift in the front location due to a stronger Atlantic-derived water influence. However, the low foraminiferal abundance, absence of planktic foraminifer and noticeable amount of opportunistic arctic species *Elphidium clavatum* in benthic assemblages point to rather unfavorable conditions probably due to a vicinity to the glacier. The suggestion about increased productivity and eastward Polar Front migration is in line with the enhanced Atlantic Water input along the Norwegian margin and through the Bear Island Trough in the Early Holocene shown by oxygen isotope and foraminiferal data, in particular in Core PSh 5159 from the Ingøydjupet Depression. At the latter location, the surface-water temperatures raised from ~ 6°C in the Younger Dryas up to ~12°C in the Early Holocene. Comparison of the records along W-E transect confirms the eastward decrease in Atlantic Water influence on the local environments even during the Early Holocene optimum. In the north, planktic and benthic oxygen isotope records show the strong Atlantic water input into the Franz Victoria Trough 7.8 - 6.9 cal ka BP. (e.g. Duplessy et al., 2001) followed by a longer sea-ice season indicated by a prominent increase in the occurrence of benthic species *Islandiella helenae/norscrossi*. A posterior environmental deterioration is mirrored by the dominance of *Elphidium clavatum* in the Late Holocene assemblages of the through.

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LOMONSOV RIDGE OFF GREENLAND 2007 (LOMROG): NEW FINDINGS ON THE ARCTIC OCEAN GLACIAL HISTORY

Martin Jakobsson¹, Christian Marcussen² and LOMROG Scientific Party

¹Department of Geology and Geochemistry, Stockholm University, 106 91 Stockholm, Sweden

²Geological Survey of Denmark and Greenland (GEUS), Øster Voldgade 10, DK-1350 København K, Denmark

The Lomonosov Ridge off Greenland 2007 (LOMROG) expedition with Swedish icebreaker *Oden*, supported by the new Russian nuclear icebreaker *50 Let Pobedy*, reached the previously unexplored areas of the southernmost Lomonosov Ridge north of Greenland. Erosion by glacier ice was mapped on the ridge crest above ~800 m water depth with *Oden*'s newly installed multibeam and chirp sonar system. From this ice eroded area two cores were taken that contained a stiff diamicton below a slightly less than 2 m thick drape of mud deposited after the last ice erosional event. These cores will allow dating of the ice erosion on the southern Lomonosov Ridge crest. After mapping portions of the Lomonosov Ridge, the Morris Jesup Rise protruding from the Northern Greenland Continental shelf, was investigated for glacial features. Remarkably large iceberg scours as deep as 1050 m below present sea level were mapped crossing the Morris Jesup Rise from West to East. A recent synthesis of glacial morphological seafloor data suggests that large ice shelves occupied parts of the Arctic Ocean during glacial maxima, ice rises were formed over the Chukchi Borderland and portions of the Lomonosov Ridge (Jakobsson et al., in press). From these ice shelves icebergs were calved with drafts deeper than 900 m that could scour the Morris Jesup Rise on their way out of the Arctic Ocean towards the Fram Strait. This presentation is on behalf of the entire LOMROG Scientific Party.

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LINKING LAND AND SEA - MULTISTOREY VALLEY FILL FROM THE MEZEN AND SEVERNAYA DVINA RIVER VALLEYS, ARKHANGELSK REGION; NW RUSSIA

Maria Jensen¹, Igor Demidov^{2*}, Eiliv Larsen¹ and Astrid Lyså¹

¹Geological Survey of Norway, N-7491 Trondheim, Norway

²Russian Academy of Sciences, Karelian Research Centre, Institute of Geology, 11 Pushkinskaya Street, Petrozavodsk, 185610, Russia, *) Deceased October 2007

River valleys provide an important link between onshore and offshore stratigraphical records, and understanding of palaeovalley deposits is important for correlation across the present shoreline. This is particularly significant in Quaternary studies because variations in methodology and databases in marine and terrestrial studies tend to generate an arbitrary boundary at the modern shoreline, resulting in lack of data and limits on idea exchange. The modern Severnaya Dvina and Mezen river systems in NW Russia are located within extensive palaeovalley systems. The palaeovalleys form depressions in bedrock, which have controlled the drainage systems in the area at least since the last interglacial. Vertically stacked marine to fluvial sediments reflect deposition during fluctuating climate and sea levels.

Lithostratigraphical investigations coupled with bedrock topography, shelf bathymetry and geomorphology from satellite images have been used to describe the valley-fill architecture for the two valley systems. Each system has been divided into a number of depositional units (storeys) separated by incision/ non-deposition, which is used to investigate the timing of aggradational versus incisional phases. Time constraints for each phase are provided by OSL ages, and aggradation and incision is linked to independent records of climate and sea level change.

The pattern of aggradation and erosion is to a large extent driven by a relative sea level change, but is overprinted by a climatic signal reflecting changes in sediment supply and discharge between cold and warm stages. Combined response to upstream and downstream forcing mechanisms suggests that direct correlations between fluvial aggradation/incision and sea level fluctuations should be used with caution. Isostatic uplift plays a significant role in driving relative sea level as well as causing upstream erosion and associated increased sediment supply. Possible catastrophic drainage of large ice dammed lakes may also have had significant impact on the valley fill architecture.

THE WARM STAGES WITHIN THE 340 KA SEDIMENT RECORD OF LAKE EL'GYGYTGYN/NE SIBERIA – A COMPARISON

Olaf Juschus¹, Martin Melles¹ and the Lake El'gygytgyn Scientific Party

¹University of Cologne, Institute of Geology and Mineralogy, Cologne, Germany

Lake El'gygytgyn, located on Chukchi peninsula/NE Siberia, is a nearly circular lake with a diameter of 12 km and a water depth of 170 m. It was formed by an impact about 3.6 million years ago. Despite the fact that the lake is situated north of the Arctic Circle, geomorphological evidence suggests that the crater was never glaciated during the entire Late Cenozoic. Thus, a full-length sediment core from Lake El'gygytgyn would yield a complete record of Arctic climate evolution, back one million years prior to the first major glaciation of the Northern Hemisphere. During the last decade the sedimentary record of the lake has become a major focus of multi-disciplinary multi-national paleoclimatic research. The International Continental Scientific Drilling Program (ICDP) has provided funding for drilling operations on the lake and in its permafrost catchment in 2008/2009. Additionally, the project became involved in the IPY under the umbrella of APEX and BIPOMAC. Pre-site surveys carried out in 1998 and 2003 recovered two 12.9 m and 16.6 m long sediment cores from the deepest part of the lake. They revealed a basal age of approximately 250 ka and 340 ka respectively and confirmed the lack of glacial erosion.

Presented here is a comparison of the main warm stages within the 16.6 m long sediment record of core Lz1024 which was recovered in 2003. To establish an age model for core Lz1024, selected sedimentological parameters (mag. susceptibility, total organic carbon, TiO₂, and biogenic silica) were systematically tuned to the northern hemisphere insolation. The tuning yielded an age of 343 ka for the base of the composite core. Down to 200 ka sediment age the tuning is confirmed by the results of IRSL dating. Sediment successions correlated with the marine isotope stages (MIS) 1, 3, 5.5, 7.1, 7.5, and 9.3 represent the main warm phases within the sediment record of core Lz1024. Compare to the sediments settled during cold phases, the warm stage sediments are usually massive with comparably high susceptibility values. This indicates an ice-free season during the summer with complete mixing of the water body. The lake bottom and the uppermost sediments were oxygenated which allowed bioturbation and oxygenation.

The warm stage sediment units are subdivided into three different types.

- **Type 1:** The sediments of the first type are characterised by biogeochemical parameters which indicate comparably low bioproductivity within the lake and a strong decomposition of organic matter at the water-sediment transition. Low shrub and arboreal pollen values provide evidence of at least relatively cold summer conditions. High susceptibility values and TiO₂ contents give indications for a complete meltout of the ice cover during the summer and mixing of the water body. This pattern is valid for the sediments settled during MIS 3 and 7.5.
- **Type 2:** Both the organic and inorganic geochemical data of this sediment type are comparable to those from Type 1 with a low bioproductivity. The susceptibility values seem to be a little bit higher. The remarkably higher contents of arboreal pollen are the main difference and indicate better growing conditions during this time. These conditions prevailed during MIS 1 and 7.1.
- **Type 3:** Especially the organic geochemistry data differ from the first two types by remarkable higher contents of organic carbon and biogenic silica, reflecting much higher bioproductivity within the water column. Due to postdepositional dissolution processes the susceptibility values decreased to lower levels. The high amount of arboreal and shrub indicates relatively warm summers. The occurrence of these peak warm sediment successions is restricted to MIS 5.5 and especially 9.3. The latter one represents the time period during the last 340 ka with the highest bioproductivity within the lake.

LATE QUATERNARY HISTORY OF STORE KOLDEWEY, NE GREENLAND, INFERRED FROM LAKE SEDIMENTS

Martin Klug¹, Bernd Wagner¹, Martin Melles¹

¹ University of Cologne, Institute for Geology and Mineralogy, Zuelpicher Str.49a, 50674 Cologne, Germany

Due to the remoteness of North-East Greenland only few studies were carried out so far to investigate the environmental and climatic history of this region. On Store Koldewey, an elongated island at 75°55'-76°45' N and 018°27'-019°10' W, studies of geomorphological features and raised marine deposits indicate that the south-eastern part of the island remained ice-free during the Last Glacial Maximum (LGM) (Hjort 1981). However, cosmogenic exposure dating shows that the elevated mountain plateaus of the island were at least partly covered by cold-based ice during the LGM (Håkansson et al. 2007).

Here we present information obtained by the investigation of the sedimentary records from lakes M1, Duck and Hjort on eastern Store Koldewey. These records were studied with a multidisciplinary approach in order to reconstruct the extent of the glaciation during the Late Glacial and Holocene, the timing and pattern of deglaciation, and the pre- and postglacial climatic and environmental history.

Two of the records contain pre-LGM sediments, which is indicated by finite (lake M1) and infinite (Duck Lake) ¹⁴C ages in the basal sections. These ages, in concert with fine-grained, partly laminated sediments, suggest that both basins already existed during the Weichselian and that glaciolacustrine sedimentation therein prevailed. Whilst the sediments in the basal section of lake M1 are consolidated those in Duck Lake are overconsolidated, probably due to overlying ice. Both basal sections are overlain by coarser sediments, which are repeatedly interspersed with fine-grained laminae and scattered pebbles. These characteristics indicate that deposition in Duck Lake occurred most likely during and after the decay of the overlying ice, whereas the absence of overconsolidated basal sediments in lake M1 point to a proximal ice margin during the LGM.

The upper sediments in lake M1 and Duck Lake and the sediment sequence from Hjort Lake are predominantly fine grained and mosses are common. Due to the presumed lack or reduced glaciation of lake M1 during the LGM the bioproductivity in this lake started 11 ka cal BP. Organic matter and sulphur accumulation in the sediment indicate a typical Holocene temperature development for East Greenland with an early thermal maximum. In addition, they display short-term fluctuations such as the 8.2 ka cooling event. The onset of biogenic productivity in the records from Duck and Hjort Lake at c. 9 ka cal BP gives a minimum age for deglaciation of these basins. Organic matter accumulation remained low during the early Holocene. This can be best explained by delayed nutrient availability. From c. 6 ka cal BP to the present higher availability of nutrients promoted the productivity in both lakes, which, however, remained variable.

The differences between the individual lakes demonstrate the necessity to study more than a single lake in a region in order to reconstruct its environmental history, and to combine the information obtained with other records available.

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ICE FREE ARCTIC OCEAN DURING THE MID-PLIOCENE WARMTH (~3 MA)?

Jochen Knies¹, Jens Matthiessen² and Christoph Vogt³

¹Geological Survey of Norway

²Alfred Wegener Institute for Polar and Marine Research

³University of Bremen

3 millions years ago, the documentation of C₃₇ alkenone-derived high sea surface temperature (SST) of ~19 °C on the Yermak Plateau (ODP Site 911) let assume that the marginal areas of the eastern Arctic Ocean were ice free during the middle Pliocene warmth. The anomalies go along with elevated SST reconstruction from dinoflagellate assemblages excluding the probability that reworked, organic-rich Mesozoic sediments were solely responsible for the warm SST. The coupled increase of marine productivity – inferred from elevated biogenic opal and C₃₇ alkenone concentration – and the clay mineral group smectite with largely absent IRD during the same interval indicate a prominent setting, which is well known from the Late Quaternary. There, compelling evidence is provided for the last deglaciation that these anomalies are deduced from sea-ice entrained sediments from the eastern Kara Sea that entered the Arctic Ocean after ice-sheet break-up and eventually flooding of the Kara Sea. However, different from this setting, is that the paleoenvironment on the Yermak Plateau during the Pliocene warmth is possibly the result of distinct changes in the hydrological cycle over Siberia, which ultimately triggered enhanced fluvial discharge/erosion of smectite-rich deposits towards the Siberian shelves. Rapid melting of ice and distinct water mass stratification in the study area under (obliquity driven) more favourable climate boundary conditions may have amplified both SST and surface water productivity. Analogues to this scenario although with significantly lower SST anomalies (max. 8-12 °C) during summer months are possibly the Arctic warming during the early twentieth century.

WESTERN SVALBARD ICE SHEET DYNAMICS THROUGH THE LAST INTERGLACIAL/GLACIAL CYCLE. TOWARDS UNLOCKING THE ICE-SHEET/OCEAN INTERACTION

Jon Y. Landvik, Helena Alexanderson and Heidi T. Ryen

Department of Plant and Environmental Sciences, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Ås, Norway

Recent reconstructions of the Late Weichselian ice sheet along the west coast of Svalbard suggest that ice streams filled the fjords and cross-shelf troughs, whereas the intervening areas were covered by dynamically less active ice (Landvik *et al.* 2005; Ottesen *et al.* 2008). The ice sheet extended to the shelf break, and surface exposure age dating suggests minimum glacier thicknesses of 300-500 m adjacent to the outer part of the Kongsfjorden ice stream (Landvik *et al.*, unpublished).

We hypothesize that this bipartite zonation within the Late Weichselian ice sheet was probably also valid for previous glaciations, and that the classic glaciation curves (e.g., Mangerud *et al.* 1998) might only represent the ice stream part of the system. Such a scenario has consequences for the understanding of the past ice sheet/ocean interaction.

Ongoing research within the IPY SciencePub project aims at reconstructing the glacial conditions in both parts of this glacial system. As a part of this effort, several classic sites in NW Svalbard are revisited to establishing a better chronology of the glacial events, a prerequisite for better correlation with the marine stratigraphy and understanding of ice sheet/ocean interaction during the extreme glacial phases.

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WEICHSELIAN GLACIAL AND LAKE HISTORY OF NW RUSSIA: WILL IT FINALLY COME TOGETHER?

Eiliv A. Larsen¹, Maria A. Jensen¹, Astrid Lyså¹, Igor N. Demidov^{2*} and Ola Fredin¹

¹Geological Survey of Norway, NO-7491 Trondheim, Norway

²Russian Academy of Sciences, Karelian Research Centre, Institute of Geology, 11 Pushkinskaya Street, Petrozavodsk 185610, Russia. *) Deceased October 2007.

The concept of repeated glaciations blocking the northwards flowing Russian rivers and resulting in huge proglacial lakes, is long known (Kvasov 1979). Reconstruction of both ice sheet configuration and lakes in time and space has proven problematic with the consequence that a coherent picture is yet to be established. So far critical data for reconstruction has been lacking, and interpretations are often by inference from other evidences. Mangerud et al. (2004) postulated a lake in the White Sea basin corresponding with the lake Komi, whereas Larsen et al. (2006) suggested a younger lake in the same area of the White Sea basin as a consequence of an ice sheet reconstruction. None of these two suggested lakes were based on physical dated evidences of the lakes themselves.

New results from field investigations, dates and satellite images from the upper reaches of the Severnaya Dvina river, i.e. distally to reconstructed Weichselian ice margins (Demidov et al. 2006), show sediments that belong to two lake phases, and a surface morphology evidencing lake drainage. From the Tolokonka site just north of the city Kotlas, several OSL dates are obtained. These indicate that the older lake phase is Early to Middle Weichselian in age, but a precise age is yet to be obtained. Correlation with the lake Komi (Mangerud et al. 2004) or the White Sea Lake (Larsen et al. 2006) is open. The younger lake phase is Late Weichselian in age, and corresponds with the Scandinavian ice sheet entering the Severnaya Dvina basin from the north. These lake sediments are separated from the older lake by a diamicton deposited either proglacially in a basin or directly by the glacier entering the basin. In the latter case the ice penetrated somewhat farther to the south during the Late Weichselian maximum glaciation than suggested by present reconstructions. Whatever that result may prove to be, the site and the area potentially provide a detailed lake and glacier lobe interaction history to be established. The surface morphology south of (distally to) the reconstructed Late Weichselian ice margin is characterized by a pattern related to lake drainage. Although only found south of this ice margin, it is still unclear whether the pattern stems from drainage of the older or younger lake phase.

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AURORA BOREALIS – EUROPEAN RESEARCH ICEBREAKER AND DEEP-SEA DRILLING VESSEL: THE CHALLENGE OF A NEW INFRASTRUCTURE

Lester Lembke-Jene¹, Nicole Biebow¹, Martina Kunz-Pirrung¹, Joern Thiede¹, Paul Egerton²

¹Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

²European Science Foundation, Strasbourg, France

Future scientific breakthroughs in marine polar research critically depend on our community's ability to perform field expeditions with state-of-the-art technologies and modern infrastructures. This will require major investments, both in terms of generating new, as well as maintaining and renovating existing infrastructure. Diverse novel tools are presently projected, also within the context of scientific needs after the IPY has ended.

We here report on the planning of a new European research icebreaker, the AURORA BOREALIS, with an all-season capability of endurance in permanently ice-covered waters and with the possibility to carry out deep-sea drilling in ice-covered deep-sea basins. AURORA BOREALIS will become the most advanced polar research vessel in the world with a multi-functional role of performing year-round interdisciplinary science expeditions in the polar oceans as well as drilling in ice-infested deep ocean basins, thus supporting the operational needs of all marine polar science disciplines for the next 35 to 40 years. The vessel is outlined to being a powerful research icebreaker with more than 45,000 tons displacement and a length of about 180 m, with an estimated propulsion power of 55 Megawatt. New technological features to be implemented include a completely novel hull design and specialized dynamic positioning systems for operations under closed sea-ice cover conditions of up to 2.5 m ice thickness, combined with advanced satellite navigation and ice-forecasting support. Two moon-pools (7x7 m each) will allow routine deployment and operation of Remotely Operated Vehicles (ROV) and Autonomous Underwater Vehicles (AUV) in ice conditions. A dedicated deep-sea drilling rig with full weather protection will enable sampling of the ocean floor in water depths down to 5000 m with 1000 m penetration under polar conditions. The modular arrangement of science space with hangars and versatile tool preparation areas, the possibility to flexibly equip the ship with laboratory or supply containers and with helicopters, addresses the needs of diverse disciplines in marine research. In this contribution, we update the potential user community on the current status of the technical design, the scientific outline and the framework of the Preparatory Phase recently started within the context of a European collaborative project, the European Research Icebreaker Consortium - AURORA BOREALIS.

MARINE EVIDENCE FOR DEGLACIATION OF THE DISKO BAY AREA, WEST GREENLAND

Jerry Lloyd¹, Matthias Moros², **David McCarthy**¹, Ian Snowball³, Per Sandgren³, Antoon Kuijpers⁴, Jan Harff², Thomas Richter⁵

¹Department of Geography, University of Durham, South Road, Durham, DH1 3LE, UK

²Baltic Sea Research Institute, Department of Marine Geology, Seestrabe 15, 18119 Rostock, Germany and Bjerknes Centre for Climate Research, Allegaten 55, 5007 Bergen, Norway

³Geobiosphere Science Centre, Department of Geology - Quaternary Sciences, University of Lund, Lund, Sweden

⁴Geological Survey of Denmark and Greenland, Oster Voldgade 10, DK-1350 Copenhagen K, Denmark

⁵Department of Marine Geology, Royal Netherlands Institute for Sea Research, 1790 AB Den Burg, Netherlands

The Disko Bay area of west Greenland has seen significant research in recent years. This research has identified links between Jakobshavns Isbrae, a major ice stream draining the West Greenland Ice Sheet, ocean circulation and climate change since the mid-Holocene. However, the history of earlier initial deglaciation of this area after the LGM remains poorly constrained.

Here we present results from recent research in Disko Bay identifying retreat of the ice sheet through Disko Bay into the fjord systems and the terrestrial realm to the east. We also identify the interaction between ocean circulation and ice margin activity – particularly Jakobshavns Isbrae - associated with this retreat and also subsequent activity during the Holocene.

During the summer of 2007 a major cruise of the RV Maria S. Merian visited Disko Bay, the Uummannaq fjord complex to the north and the shelf to the west of this area. One of the aims of this cruise was to investigate the longer term history of deglaciation and oceanic evolution of the Disko Bay area and also the Uummannaq fjord complex to the north. Here we present the preliminary findings from this investigation based on gravity cores collected during the cruise.

Cores were collected from the extension of the deep water trough, Egedesminde Dyb, from the shelf west of Disko Bay. This trough is assumed to have been formed by an extension of Jakobshavns Isbrae to the shelf edge during late Pleistocene extreme glaciation. Magnetic susceptibility and scanning XRF data from a transect of cores from this trough through Disko Bay to the current coastline identify periods of rapid fine grained sedimentation associated with the meltwater plume from the retreating ice front. A basal date from a core west of Disko Bay provides a minimum age for deglaciation of the outer trough (retreat of the ice stream) of c. 11 ka cal BP. Previous research has shown that the ice stream had retreated at least mid way across Disko Bay by c. 10.2 ka cal BP, retreating into the present day Jakobshavns Isfjord at c. 8 ka cal BP. These dates suggest a rather gradual deglaciation of the ice sheet from the shelf through Disko Bay, reaching the current coastline by the early Holocene.

LATE HOLOCENE RELATIVE SEA-LEVEL RISE AND THE NEOGLACIAL REGROWTH OF THE GREENLAND ICE SHEET

Antony Long¹, Sarah Woodroffe¹, Sue Dawson² and David Roberts¹

¹Department of Geography, Durham University, Science Site, South Road, Durham DH1 3LE, UK

²School of Geography and Geosciences, Irvine Building, University of St Andrews, North Street, St Andrews, KY16 9AL, UK

It is hypothesised that the Greenland Ice Sheet (GIS) retreated tens of kilometres inland of its present margin during the Holocene thermal maximum before advancing during the late Holocene to reach its maximum extent during the Little Ice Age when the “Historic Moraines” of the Late Neoglacial formed. This readvance was associated with a reloading of the Earth’s crust by ice that caused glacio-isostatic depression and relative sea-level (RSL) rise in parts of west and south Greenland. The spatial pattern, magnitude and timing of this reloading provides constraints on ice sheet response to climate, Earth rheology, as well as a context against which to interpret short-term (decadal) geodetic observations of vertical crustal displacements in Greenland. Here we present the results of a programme of study designed to reconstruct the magnitude and timing of the rise in late Holocene RSL in the Sisimiut area of west Greenland, from a field site located 175 km east of the present ice sheet margin. Three isolation basins above present sea-level track RSL fall from c. 14 m asl at 5.7 k cal. yr BP to present sea level by 3.7 k cal. yr BP. Three drowned isolation basins constrain the fall in RSL below present to a lowstand of c. -3.60 m at c. 2.2-1.8 k cal. yr BP, and a subsequent rise in RSL to present at an average rate of c. 1.7 mm yr⁻¹. The timing of the RSL minima occurs c. 1 k yr after the onset of the Early Neoglacial cooling as defined in Greenland ice cores, fjord sediment archives, as well as lake records. We compare our long-term rate of RSL rise with recent GPS observations in West Greenland by Dietrich *et al.* (2005) which show subsidence (up to 4 mm yr⁻¹) close to the present ice sheet margin and uplift (of c. 1-2 mm yr⁻¹) at the outer coast. The contrast we see between late Holocene subsidence, inferred from our isolation basins, and recent GPS-observed uplift demonstrates that; a) the area of peripheral subsidence around the ice sheet margin was more extensive in the late Holocene than at present, and; b) that there has been a switch from subsidence to uplift at some point in the late Holocene. Further research is required to develop century to millennial-scale RSL records during the last 2 k yr BP to determine when these changes occurred.

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ARCTIC OCEAN MN CONTENTS AND SEDIMENT COLOUR CYCLES

Ludvig Löwemark, Martin Jakobsson, Magnus Mörth and Jan Backman

Department of Geology and Geochemistry, Stockholm University, 106 91 Stockholm, Sweden

The cyclical variations in colour and Mn content observed in many sediment cores from the central Arctic Ocean have been interpreted to represent climatically controlled changes in the input of Mn from northern Siberia and/or variations in the intermediate and deep water ventilation of the Arctic basins, although a diagenetic component has not been excluded. It was therefore suggested that these manganese/colour cycles correspond to warm phases that correlate to marine oxygen isotope stages and, thus, could be used for chronostratigraphic correlation between cores from the central Arctic Ocean where traditional isotope stratigraphy is difficult or impossible to establish due to the lack of calcareous microfossils.

A reinvestigation of core 96/12-1pc using the new Itrax XRF core scanner at Stockholm University confirms that the dark brown coloured sediment cycles are indeed controlled by variations in Mn content, although changes in the source region of the sediment may override the Mn-colour signal in certain intervals, such as the conspicuous grey layer found in many cores in the Eurasian basin. The prominent Mn-colour cycles show no correspondence to any of the other measured elements. This decoupling of the Mn and the bulk chemistry of the sediment is taken to indicate that the cycles observed are caused by variations in water column ventilation and/or riverine input rather than variations in sediment source or diagenesis. We therefore conclude that the Mn cycles do represent warm phases with increased ventilation and/or riverine input, and that they consequently could be used for a first order chronostratigraphic correlation on at least a regional scale in the central Arctic Ocean.

XRF scanner measurements of Mn in neighbouring cores from the Lomonosov ridge reveal great similarities in the Mn cycles between the cores, especially in the upper part of the cores. In the older part of the record, however, local variations in cycle thicknesses and/or occurrences make detailed correlations considerably more difficult although the overall Mn-pattern show strong similarities in between the cores. We also note that regional variations regarding the cycle definition do exist and poorly ventilated areas may lack the brown manganese enriched sediment cycles. Despite remaining obstacles we feel that Mn cycles have great potential to become a unifying tool for tying stratigraphies in and between the Arctic basins.

A SUDDEN WATER LEVEL DROP OF THE WHITE SEA ICE LAKE DURING THE YOUNGER DRYAS

Juha-Pekka Lunkka¹, Niko Putkinen², Arto Miettinen³, Matti Saarnisto⁴

¹Institute of Geosciences, P.O. Box 3000, FIN-90014 University of Oulu, Finland

²The Geological Survey of Finland, P.O. 97 FIN-67101 Kokkola, Finland

³Norwegian Polar Institute, Polar Environmental Centre, N-9296 Tromsø, Norway

⁴Finnish Academy of Science and Letters, Mariankatu 5, FIN-00170, Finland

The White Sea Basin and the adjacent areas to the west in Russian Karelia deglaciated during the Late Weichselian between ca. 17kyr to 11.5 kyr. In most parts of the White Sea Basin, the margin of the Scandinavian Ice Sheet terminated into the glacial lake which occupied the present White Sea and the onshore areas. Although previous work has shown that the ice lake existed in front of the ice sheet in the White Sea Basin, little is known about the extent and the water level history of this glacial lake. Here we present results of the shore displacement study in the Belomorsk area in order to shed light on the development of the large ice lake around the White Sea Basin.

In order to define the shore displacement history of Russian Karelia, the isolation contact of sediment cores from six raised coastal lake basins in the Belomorsk area between 45 metres to 134 metres a.s.l. were determined using a lithological characterization of the core sediments and the diatom analysis. The isolation contact of each sediment core was also dated with AMS ¹⁴C method.

The results indicate that in most basins studied the isolation contact is sharp where laminated or massive clay and silt, often poor in diatoms, change into organic-rich clay or gyttja abundant in diatoms. Diatom results suggest that both minerogenic clay and silt and organic-rich clay and gyttja were deposited in a freshwater environment. In some of the basins the minerogenic silt and clay sediments include species such as *Diatoma moniliformis*, *Cymbella microcephala* and *Cyclotella striata* suggesting that the basins were isolated from a large lake. At the isolation boundary the occurrence of *Fragillaria* species is very characteristic and above the isolation boundary the diatom taxa is typical for small lake basins. Seven AMS ¹⁴C dates from the isolation contacts of the lake basins between 134 metres to 72 metres yield ages 10 190 ± 60 to 10 360 ± 60 years BP. The lowest basin at 45 metres a.s.l. was isolated at 8 880 ± 50 years BP.

The results of our study suggest that at around 10 200 years BP (ca. 12 000 cal BP) ago the water level of a large glacial lake in the Belomorsk area, which was a part of a substantial glacial lake in the White Sea Basin area, experienced a sudden water level drop of more than 60 metres. As a result of this a huge amount of glacial meltwater was released most probably through the neck of the White Sea into the Barents Sea. This sudden water level drop of the glacial lake in the White Sea Basin must have also affected the behaviour the eastern flank of the Scandinavian Ice Sheet and the local climate at around 12 000 cal BP ago.

WERE NOVAYA ZEMLYA AND THE BARENTS SEA ICE FREE ABOUT 30 KA?

Jan Mangerud¹, Darrell Kaufman², Jesper Hansen³ and John Inge Svendsen¹

¹Department of Earth Science and Bjerknes Centre for Climate Research, University of Bergen, Allégt. 41, 5007 Bergen, Norway

² Department of Geology, Northern Arizona University, Flagstaff, AZ 86011, USA

³Department of Natural Science, Tromsø University Museum, N-9037 Tromsø, Norway

We obtained ¹⁴C ages on 37 samples of mollusc shells from Novaya Zemlya, located under the eastern part of the Barents-Kara Ice Sheet during the Late Weichselian (Mangerud et al 2008). Most samples yielded ages in the range of 48-26 ¹⁴C Kyr. Such old samples are sensitive to contamination by young ¹⁴C and therefore their reliability was assessed using replicate analyses and amino acid geochronology. The extent of aspartic acid racemization (Asp D/L) indicates that many of the ¹⁴C ages are correct, whereas some are minimum ages only. The results indicate that Novaya Zemlya was ice-free about 35-27 ¹⁴C Kyr, possibly even earlier. Corresponding shorelines up to >140 m a.s.l. indicate a large Barents-Kara Ice Sheet during early marine isotope stage (MIS) 3. The duration of ice cover during the Late Weichselian (MIS 2) was calculated by applying the D/L values to a published kinetic equation for Asp racemization. The model indicates that the duration of ice cover was less than 3000 years if the basal temperature was 0°C, and less than 10,000 years if the basal temperature was -5°C. If Novaya Zemlya was deglaciated at the beginning of the Holocene this means that it was not overridden by glacier ice until the later part, or even after the Last Global Glacial Maximum. These results are consistent with published results from Svalbard and northern Russia; in both places a large MIS 4/3 Barents-Kara Ice Sheet is postulated to have retreated about 50 Kyr followed by an ice-free interstadial that lasted up to about 25 Kyr.

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INVESTIGATIONS INTO NOVEL CHEMICAL MARKERS FOR PAST SEA ICE

Guillaume Massé¹, Thomas Brown¹, Simon Belt¹, Marie Alexandrine Sicre², Xavier Crosta³,
Katrine Husum⁴ and Steve Rowland¹

¹SEOES, University of Plymouth, UK

²LSCE, CNRS, France

³EPOC, CNRS, France

⁴Geology Department, University of Tromsø.

In the current project, we are investigating the potential to use chemical biomarkers of sea-ice associated diatoms to serve as a proxy of sea-ice cover in the Arctic.

To date, our investigations have revealed that a restricted number of diatoms biosynthesise a class of secondary metabolite chemicals termed highly branched isoprenoids (HBIs). These chemicals are ubiquitous to marine sediments, but only one structural form of the HBIs exists in Arctic sea-ice. In turn, this chemical (a C₂₅ HBI mono-unsaturated alkene – IP₂₅) can almost certainly be associated with some *Haslea* spp. which are known to occur in Arctic sea-ice.

In order for the HBI biomarker to be useful as a historical indicator of past sea-ice, its behaviour in sediments also needs to be understood. Therefore, we have obtained sediment cores from the East-West Canadian Arctic (ArcticNet 2005 and 2007 cruises) and surface sediments from the Greenland Sea area (Warmpast 2006 & 2007 cruises) and analysed them for their biomarker content. We have detected the mono-unsaturated HBI alkene, previously found in sea-ice, in all the sediment samples. In addition, the HBI biomarker has been readily detected in a sediment core collected from Barrow Strait (Canadian Arctic) covering the entire Holocene. These data, together with analyses from sediments obtained from the North Icelandic shelf (MD99-2275) will be discussed, as will the potential to use the HBI biomarkers for sea ice reconstruction in the Antarctic.

INTERACTIONS BETWEEN ICE STREAM ACTIVITY, OCEAN CIRCULATION AND CLIMATE CHANGE IN THE DISKO BUGT – UUMMANNAQ AREA OF WEST GREENLAND DURING THE HOLOCENE

David McCarthy^{1*}, Jerry Lloyd¹, Matthias Moros², Ian Snowball³, David Roberts¹ and Andreas Vieli¹

¹Department of Geography, Durham University, Science Laboratories, South Road, Durham

²Bjerknes Centre for Climate Research, Allegaten 55, 5007 Bergen, Norway and Baltic Sea Research Institute, Seestrasse 15, 18119 Rostock, Germany

³GeoBiosphere Science Centre, Department of Geology – Quaternary Sciences, Lund University, Sölvegatan 12, SE-223 62, Lund, Sweden

Recent rapid changes (acceleration, thinning and retreat) in ice stream behaviour have been widely documented in high-latitude environments (e.g. Rignot and Kanagaratnam, 2006). These include the collapse and retreat of Jakobshavns Isbrae in West Greenland. Although recent climate warming may be one possible cause, ice dynamic changes and ocean warming have also been suggested as alternative mechanisms for propagating rapid changes in tidewater glaciers. However, longer-term records are needed to assess whether these are unique changes linked to recent global warming, or within the natural variability of these systems.

This study aims to understand the interactions between ice stream activity, ocean circulation and climate change in the Disko Bugt - Uummannaq area of central West Greenland since deglaciation. To do this, high-resolution marine cores from the Vaigat, the main conduit for icebergs and meltwater exiting Disko Bugt, and a distal location on the continental shelf west of Uummannaq Fjord are being investigated. Changes in benthic foraminiferal assemblages throughout the distal core reflect changes in the relative temperature of the West Greenland Current (WGC). The WGC is a relatively warm and saline current that has the potential to bring relatively warm water into contact with the basal portions of tidewater glaciers in west Greenland. Variations in relative temperature of the WGC therefore have the potential to influence ice stream behaviour. Relatively cool water fauna at the base of this core are linked to deglaciation of the continental shelf west of Uummannaq during the early Holocene. Up core variations between warm and cold-water faunal assemblages are indicative of changes in the relative strength of the WGC flowing into this area. This provides a proxy record for marine forcing that has the potential to influence ice margin dynamics. In order to examine this relationship, the ice distal record is compared to a core from the Vaigat, closer to the ice margin, and other records from eastern Disko Bugt. The sedimentology and faunal data from cores close to the ice stream outlets will record variation in meltwater and sediment flux associated with changes in ice stream behaviour. By comparing the distal and proximal records we can assess the relative importance of ocean versus climate forcing on ice stream behaviour.

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REVERSE PHASE VALLEY AND SHELF GLACIATIONS ON NORTHERNMOST GREENLAND - THE IMPORTANCE OF AN OPEN ARCTIC BASIN AS A MOISTURE SOURCE

Per Möller¹, Nicolaj K. Larsen¹ and Kurt Kjær²

¹Quaternary Sciences, Dept. of Geology, GeoBiosphere Science Centre, Lund University, Sölvegatan 12, SE-22362 Lund, Sweden

²Natural History Museum of Denmark, Geological Museum, University of Copenhagen, Øster Voldgade 5-7, DK-1350 Copenhagen, Denmark

Many of the trough valleys trending north towards the coastal plain bordering Johannes V Jensen Land on northernmost Greenland have prominent end moraines crossing their valley mouth openings. During the LongTerm project (2006-2007) the relations between valley depositional systems and their linkage to the coastal plain sediments have been studied in the Constable Bugt area. This embayment is the distal end of Sifs valley, which in its proximal end hosts the Sifs glacier, being one of many outlet glaciers from ice-fields within the alpine mountain range in the south, blocking this northernmost area of Greenland from the Greenland Ice Sheet. Eight sedimentary units (A-H) have been identified, of which three are glacial tills, intercalated with marine, glaciolacustrine and fluvial sediment units.

The lower till (unit A) is related to a regional ice advance and till deposition from ice flowing along the northern coast of Greenland from west towards east. During deglaciation there was a marine inundation with deposition of *marine sediments (unit B)* reaching at least 40 m a.s.l. The oldest retrieved ¹⁴C dates on molluscs suggest a deglaciation age of c. 11-10.5 cal kyr BP. The wide end moraine at the valley mouth consist of the *intermediate till (unit D)*, but also of intercalated *marine sediments (unit B)* and thrust blocks of *glaciolacustrine sediments (unit C)*. This end-moraine zone relate to an expansion of the ice fields within the alpine mountains in the south, resulting in outlet glacier advances. The Sifs glacier expanded northward more than 20 km in relation to its present position, reaching close to the present coast and depositing till also outside the end moraine on top of marine sediments. Thus the end moraine zone is not a terminal moraine of this advance, but represents a substantial halt in the subsequent ice front recession. Age constraints on this advance are given by ¹⁴C ages on molluscs in incorporated marine sediments (10-9.5 cal kyr BP) and organic remains in ice-thrust unit C silt (10.7-9.9 cal kyr BP), thus giving the maximum age on this event. A large, but now dissected, *sandur* was deposited outside the end-moraine zone (*unit E*) during this event.

Inside the end-moraine zone are numerous exposures of undisturbed *glaciolacustrine sediment (unit F)* with organic remains dated to 6.4-4.9 cal kyr BP. These sediments are draped in a patchy manner with a thin diamict, *the uppermost till (unit G)*, but more often with a lag of boulders, often striated and up to sizes of 1.5 m. We propose, that this till represent a second Holocene ice advance, in time framed between the retrieved ¹⁴C ages of the underlying *unit F* silt and ¹⁴C ages from organic remains in *alluvial fan deposits (unit H)*, cutting through the *unit F and G* sediments (c. 5 cal kyr BP).

This scenario with two major valley glacier advances during the Holocene is of course intriguing as such having not previously been recorded on Greenland. However, an open arctic ocean in the early to middle part of the Holocene, as indicated by the presence of high energy beaches along the north coast of Greenland (beach-face sediments, upper part of unit B marine sequences), would have given the mandatory moisture source for such an expansion. Low temperatures are not what drive glacier advances in this at present polar dessert; it is a milder climate with increased precipitation!

POSTGLACIAL EVOLUTION OF THE WHITE SEA BASIN (WESTERN ARCTIC) BASED ON DINOFLAGELLATE CYST ANALYSIS

Yekaterina Novichkova¹, Yelena Polyakova² and Henning Bauch³

¹Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia

²Geographical Faculty, Lomonosov Moscow State University, Moscow, Russia

³Mainz Academy of Science, Humanities and Literature, c/o IFM-GEOMAR, Kiel, Germany

The White Sea located in the western part of the Eurasian Arctic is a typical mediterranean shelf basin, which connected with the Barents Sea via the narrow and shallow strait. It is one of the most sensitive Arctic region influenced by both Atlantic and Polar waters. The major peculiarities of modern hydrological, hydrobiological and sedimentation processes in the White Sea are governed by the significant riverine discharge, extensive Atlantic water advection, and its inland position (Lisitzin et al., 2003; Berger and Naumov, 2000). The distinctive features of postglacial development of the White Sea were caused by the consistent degradation of the Scandinavian Ice Sheet during the Late Pleistocene and Holocene and the increase in advection of the Barents Sea waters. On the basis of previous geological and micropaleontological (diatoms, pollen-and-spores) investigations of numerous sediment cores from the White Sea the general stratigraphical scheme was elaborated (Djinoridze, 1971, Maliasova, 1976, Khitinskiy, 1987, Nevesskiy et al, 1977). Unfortunately, this scheme was not supported by any radiocarbon data till now. In this report we represent the first radiocarbon and radiochronology data obtained for sediment cores from the White Sea and paleoenvironmental reconstructions based on distribution patterns of aquatic palynomorph assemblages in the White Sea sediments. The previous study of dinocyst assemblages in the surface sediments from the White Sea, which were carried out for the first time in this sea (Novichkova, Polyakova, 2007; Polyakova et al., 2003, Golovnina, Ployakova, 2005) and revealed regularity of dinocyst assemblages formation in the surface sediments of the White Sea were used as a principal proxy for reconstruction of postglacial environments in the White Sea.

For the purposes of reconstructions of postglacial environments in the White Sea we carried out detail study of aquatic palynomorph assemblages in sediment core 6062 obtained from the Onega Bay of the sea (water depth 71 m, total sediment recovery 338cm), which according to AMS ¹⁴C data encompasses the last approximately 8500 years. The following major stages in the evolution of the White Sea basin were reconstructed: approximately 10-12 thousand years ago, when the Barents Sea waters entered to the White Sea through the shallow-water Gorlo Strait, the southern part of the White Sea (Onega Bay) represented the fresh water basin. Concentration of dinocysts (100-400 cyst/g) and green algae (200-500 algae/g) in these sediments are of very low abundances, that assume heavy sea-ice and climate conditions in this shallow and freshen water basin. The middle of Preboreal period was marked by interruption of sedimentation processes in the Onega Bay. The increase of the Onega River outflow to the White Sea was reconstructed for approximately 10300 years ago on the bases of sharp increase in concentration of freshwater green algae (up to 4000 algae per gram dry sediment) in aquatic palynomorph assemblages. Cosmopolitan dinocysts from *Operculodinium* group (with Arctic morphotypes) were dominated species during this time. After Preboreal period ice almost destroyed and fully marine conditions has been set in the White Sea. Atlantic period was characterized by the maximum of species diversity of dinocyst associations. Several new species appeared (*Spiniferites ramosus*, *Brigantedinium* spp.) in the White Sea. Relatively cold conditions in Subboreal period were mainly caused by changes in concentrations *Islandinium minutum* group (1800 cyst/g) as indicator sea ice cover. After approximately 2400 years ago modern hydrological conditions began in the White Sea.

Dinoflagellate cyst analysis also has been used in two short sediment cores from the central part of the White Sea to reconstruct high-resolution hydrographical changes during past 250 year. As revealed by chronology data (Aliev et al., 2004), core 4719 and core 4706 from the outer part of Kandalaksha Bay (water depth 277 m) mainly cover the time between nowadays and 1750 year. According to radiochronology and fluctuation of relative abundance of polar and subpolar species in aquatic palynomorphs assemblages compositions this period divided into several climatic intervals.

Species composition was compared with modern situation and have shown that the ratio of polar and subpolar species to other cysts have strong tendency of general decrease upcore till the middle of 19 century, and indicates heavy conditions in the White sea region which called Little Ice Age in Europe.

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PAST ICE SHEET EXPANSION AND LARGE-SCALE GLACIER-INFLUENCED SEDIMENTATION ON THE GREENLAND CONTINENTAL MARGIN

Colm Ó Cofaigh¹, Jeffrey Evans² and Julian A. Dowdeswell³

¹Department of Geography, Durham University, Durham, DH1 3LE, UK

²Department of Geography, University of Loughborough, Loughborough, LE11 3TU, UK

³Scott Polar Research Institute, University of Cambridge, Cambridge CB2 1ER

The advance and retreat of large polar ice sheets during past glacial maxima can be reconstructed from the marine geophysical and geological record of high-latitude continental margins. On the east and NE Greenland margin, expansion of the Greenland ice sheet across the shelf is recorded by a range of geomorphological and geological data mostly interpreted from seismic records. Offshore of Keiser Franz Joseph Fjord a prominent mid-shelf moraine represents a minimum limit for the ice sheet at the LGM. Distal to this moraine, sediment units interpreted as till from seismic records extend to the shelf edge. A spectacular suite of submarine channels between 72°-75°N connects the shelf and upper slope in this region to the abyssal depths of the Greenland Basin. The channels are up to 100 m deep, 4 km wide, and they extend for a distance of about 300 km down the continental slope. Side-scan and sub-bottom profiler data indicate that the channels are floored by sandy sediments and they are bordered by well developed, acoustically stratified levees. Cores from the channels and further upslope are dominated by mass-flow deposits including debris flows (on the upper slope) and turbidites (in the channels). The Greenland Basin channel system would have provided a major sediment transport pathway from the shelf to the abyssal depths of the basin. Radiocarbon dates indicates that mass-flow activity in the channels had ceased by 13,000 yr BP. The channels were thus last active during the last deglaciation. This implies an extensive Late Weichselian Greenland Ice Sheet that advanced across and probably reached the shelf edge, to at least as far as 75°N, delivering debris and sediment-laden meltwater onto the upper slope. Recent marine geophysical research from NE Greenland shows direct evidence for grounded glacier ice flowing across the continental shelf in the form of streamlined subglacial bedforms in the surface of a continuous soft sediment layer in Westwind Trough. These bedforms indicate that the Greenland Ice Sheet extended to at least the middle shelf in this region during the most recent ice advance across the shelf. Slope and shelf core records suggest this to be during the Late Weichselian glaciation. The bedforms also imply that zones of fast-ice flow (ice streams) were an important glacio-dynamic feature of the ice sheet.

CONSTRAINTS ON THE PLEISTOCENE CHRONOLOGY OF SEDIMENTS FROM THE LOMONOSOV RIDGE

Matt O'Regan^{1,2}, John King², Jan Backman³, **Martin Jakobsson**³, Heiko Pälike⁴, Kate Moran², Clifford Heil², Tatsuhiko Sakamoto⁵, Thomas M. Cronin⁶ and Richard W. Jordan⁷.

¹School of Earth, Ocean and Planetary Sciences, Cardiff University, UK

²Graduate School of Oceanography, University of Rhode Island, Narragansett, USA

³Department of Geology and Geochemistry, Stockholm University, Sweden

⁴National Oceanography Centre, Southampton, UK

⁵Institute for Research on Earth Evolution (IFREE), Japan Agency for Marine Earth Science and Technology (JAMSTEC).

⁶US Geological Survey, Reston, Virginia, USA

⁷Department of Earth & Environmental Sciences, Faculty of Science, Yamagata University, Japan

Three sites cored during the Integrated Ocean Drilling Program's Expedition 302, the Arctic Coring Expedition (ACEX), provide a 27-meter continuous sedimentary section from the Lomonosov Ridge in the central Arctic Ocean. Using two key biostratigraphic datums, the magnetic inclination record and cyclic variations in both bulk and magnetic mineral grain size, a constrained cyclostratigraphic age model is presented for the last 1.2 Myr. Through stratigraphic correlation, the derived age model can be applied to neighboring cores from past expeditions to the Lomonosov Ridge (Ps-2185-6 and 96/12-1PC). Beyond 1.2 Myr, cyclic changes in sediment composition can either be tied directly to 41-kyr glacial cycles or linked with precessional changes in insolation, providing two options with different implications for the nature and driving forces of lithologic variability in central Arctic sediments. The inability to resolve this ambiguity arises from deterioration in core quality and recovery below 27 mbsf. Despite these limitations, the age-calibrated ACEX record illustrates both a reduction in sedimentation rates and the flux-rate of coarse fraction material between the late Pliocene / early Pleistocene and MIS 6, potentially indicating deposition under perennial ice conditions.

QUANTIFYING GLACIER MASS BALANCE AT THE EDGE OF THE SCANDINAVIAN ICE SHEET DURING THE YOUNGER DRYAS

Brice R. Rea¹ and David J.A. Evans²

¹Geography and Environment, School of Geosciences, University of Aberdeen, Aberdeen AB24 3UF, UK

²Department of Geography, University of Durham, South Road, Durham DH1 3LE, UK

Øksfjordjøkelen is located at ~70°N on the Troms-Finnmark border in North Norway. During the Younger Dryas, it was just beyond the margin of the Scandinavian Ice Sheet. At this time the major fjords in Troms and Finnmark were ice-free with outlet glaciers from the icefield filling a number of smaller side valleys and reaching the sea. Only one outlet glacier, Sörfjorddalen, is temporally well-constrained by ¹⁴C dating and association with the Main Shoreline (associated with a period of minimal crustal rebound dated to the Younger Dryas). Sörfjorddalen is reconstructed using a valley centre-line iterative model and assuming a no-slip basal boundary condition. This assumption of cold-based ice is supported by the geomorphological evidence of angular bouldery fronto-lateral moraines formed during the Younger Dryas. The Equilibrium Line Altitude (ELA) for Sörfjorddalen is calculated using both the Balance Ratio and Accumulation Area Ratio methods, and is used to constrain the snout positions (generally to mapped moraines) of the other outlets. An empirical ELA temperature-precipitation relationship was used to define limits of climate change required to sustain the reconstructed icefield. Calculations of ice flux through the ELA were used to further constrain the mass balance characteristics of the reconstructed icefield.

THE GEOCHRONOLOGY AND DYNAMICS OF SOUTHEAST SECTOR OF THE GREENLAND ICE SHEET DURING THE LAST GLACIAL MAXIMUM

David H. Roberts^{1*}, Antony J. Long¹, Christoph Schnabel², Stewart Freeman³, Matt Simpson⁴

¹Department of Geography, Durham University, Science Laboratories, South Road, Durham, DH1 3LE, United Kingdom

²NERC Cosmogenic Isotope Analysis Facility, Scottish Enterprise Technology Park, East Kilbride G75 0QF, United Kingdom

³Scottish Universities Environmental Research Centre, Scottish Enterprise Technology Park, East Kilbride G75 0QF, United Kingdom

⁴Department of Earth Sciences, Durham University, Science Laboratories, South Rd, Durham, DH1 3 LE, United Kingdom

The southeast sector of the Greenland Ice Sheet is currently experiencing rapid changes in mass balance and ice sheet dynamics at low elevations. However, it is uncertain to what extent these changes are typical of the behaviour of this sector of the ice sheet because our understanding of the longer-term controls on ice sheet dynamics in this region is limited. Two models exist for the Last Glacial Maximum (LGM) ice sheet in southeast Greenland. The first “minimum” model envisages a restricted ice sheet, with exposed nunataks in coastal areas and limited ice extent onto the continental shelf fed by ice flowing through bedrock troughs. A second, “maximum” model entails a thicker ice sheet with limited coastal nunataks, ice filling the coastal valleys and extending across the entire continental shelf. Radiocarbon dates on foraminifera collected from seabed cores on the southeast Greenland continental shelf suggest that the ice sheet reached a maximum extent at c. 22 k cal. yr BP, before retreating, perhaps as early as c. 17.0 k cal. yr BP, and reaching the present coast at c. 10 k cal. yr BP.

This paper presents the results of a study designed to test these different ice sheet models based on geomorphological mapping and cosmogenic isotope analyses in the Torqwertivit Imiat valley, an area to the east of the coastal town of Anmassalik. ²⁶Al and ¹⁰Be measurements on abraded bedrock surfaces in blockfield terrain above local trimlines yield surface exposure ages of c. 11.8 to 10.3 ka. This demonstrates warm-based glacial erosion of high level (c. 750 m asl) surfaces, followed by trimline formation during deglaciation and intense post-glacial weathering. Our work constrains minimum ice thickness during the LGM to at least 750 m and supports a “maximum” ice sheet model in this sector of the GIS. Ice sheet retreat from the continental shelf to the southern edge of Sermilik Fjord is dated to c. 11.1 to 9.7 ka and helps constrain the timing of the early Holocene retreat of the Helheim ice stream. Within the Torqwertivit Imiat valley, age determinations from glacially abraded terrain above the local marine limit on the coast (11.1 – 9.7 ka) and those from 10 km up-valley (12.8 – 9.9 ka), suggest rapid surface ablation during these intervals, coincident with rapid atmospheric warming observed in the Greenland ice core records.

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IPY OUTREACH, EDUCATION, AND POLAR SCIENCE DAYS

Rhian Salmon

IPY International Programme Office

What legacy will APEX leave in IPY Outreach ?

The International Polar Year (IPY) 2007-8 is in full swing, and it's not just for scientists. This is an incredible opportunity to involve the public with polar science and raise awareness about critical issues facing the polar regions. Scientists from a wide range of disciplines and countries are becoming involved in outreach activities that are unique to their project and reach a wide range of audiences. Quarterly IPY Science Days are also now being organised in order to develop easy ways for the IPY Community to raise awareness of the polar regions and their research. Several APEX participants are already very active in education and outreach. This talk and discussion will explore ways of bringing these activities to a larger international audience and involve more participants, especially those early in their scientific career.

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QUATERNARY LANDSCAPE DYNAMICS OF WESTERN BERINGIA – PERMAFROST RECORDS FROM THE LAPTEV SEA COASTAL LOWLANDS

Lutz Schirrmeister, Sebastian Wetterich, Guido Grosse, Andrei Andreev, Frank Kienast and Hanno Meyer

The hydrological regimes in the periglacial landscape changed repeatedly during the studied Late Quaternary period (fluvial, proluvial, and thermokarst-dominated). Erosional events occurred as a consequence of seismotectonic activity and permafrost degradation. The studied permafrost sequence covers a time of various climate variations. The corresponding stratigraphic configuration of the Late Pleistocene to Holocene sequence correlates well with the regional stratigraphy in northeastern Siberia, the Eurasian equivalents (Early, Middle, and Late Weichselian, Holocene), and marine analogues (MIS 4 to 1).

Meandering fluvial systems that reached out parallel to today's coastal mountains characterized the Early Weichselian lowlands. According to U/Th ages of frozen peat layers and luminescence dating of sandy deposits fluvial accumulation occurred between 100 and 50 kyr BP. The younger boundary is also confirmed by radiocarbon-dated plant remains. Similar horizons of fluvial sands below Ice Complex deposits were found in many locations: at the western Laptev Sea coast in front of the Pronchishchev Ridge, in the western Lena River Delta along the Olenyeksky channel parallel to the Chekanovsky Ridge, and on the Bykovsky Peninsula southeast of the Lena Delta in front of the Kharaulakh Ridge.

Great shifts in many environmental conditions are evident with the beginning of the Middle Weichselian interstadial in connection with the Ice Complex formation. The formation of large syngenetic ice wedges and buried cryosols clearly indicate landscape conditions that were stable over long periods on flat accumulation plains in front of the mountain ridges during this interval. Syngenetic ice wedges continued to develop with continuous sedimentation during the Last Glacial Maximum period. The highly continental climate during this period, characterised by a strong seasonality of air temperatures and hydrology, appears to be a precondition for the accumulation of fine-grained, ice-rich deposits. Extensive perennial snowfields in the mountains resulted in nival processes, seasonal slopewash and solifluction, and seasonally active melt water brooks, providing the sediment material for the Ice Complex. This special periglacial landscape directly influenced the development of regional ecosystems.

The postglacial degradation of permafrost by thermokarst processes and the transgression of the Arctic shelf seas were the most radical environmental impacts on the entire Arctic and Subarctic Siberian lowlands during the Late Pleistocene – Holocene transition period. Ice-rich permafrost sequences in Siberia therefore often exhibit sedimentary gaps in the latest Pleistocene deposits because of thermokarst processes and discontinued accumulation. A strong reorganization of hydrological systems and the entire periglacial landscape is evident during this highly dynamic transition period. A general landscape transformation occurred from Late Pleistocene accumulation plains to a strongly thermokarst-dominated relief. Thermokarst subsidence had an enormous influence on the periglacial hydrological patterns, the sediment deposition, and on the composition and distribution of floral and faunal communities. Climate deterioration, lake drainage, talik refreezing, pingo growth and new formation of polygonal ice wedge systems occurred during the middle to late Holocene. The region was reached by the post-glacial sea level rise during the middle Holocene, triggering thermo-abrasion of ice-rich coasts and the marine inundation of thermokarst depressions.

THE PERMAFROST RECORD OF ELGYGYTGYN IMPACT CRATER

Georg Schwamborn¹, Grigory Fedorov², Lutz Schirrmeister¹, Hanno Meyer¹ and Hans-W. Hubberten¹

¹Alfred Wegener Institute for Polar and Marine Research, 14473 Potsdam; Germany

²Arctic and Antarctic Research Institute, Bering Street, 199397 St. Petersburg, Russia

Elgygytgyn Impact Crater on the Chukotka Peninsula provides the unique opportunity to identify recent to Late Pleistocene permafrost conditions in terrestrial deposits and to trace back the permafrost history when using suitable proxy data with the adjacent lake sediment archive. At maximum this may retrieve a palaeoenvironment history containing changes in permafrost conditions back to > 3 Myr BP, the time of the meteor impact. Knowledge about the Late Quaternary changes as verified by terrestrial archives provide an interpretation scheme that can be applied to more ancient portions of the glacial cycles using the lake sediments.

Currently, the weathering detritus at Elgygytgyn Crater is created under permafrost conditions. It passes through typical mechanisms of periglacial landscape dynamics (i.e. solifluction, surface wash, thermo erosion, river erosion) into the lake, which is placed in the central basin. Based on field observation and laboratory analysis of frozen ground deposits several conclusions are highlighted describing periglacial dynamics during the Late Quaternary. (1) Subaerial terrace formation resulting from slope debris deposition was initiated during the Late Pleistocene / Holocene transition. During Late Holocene the accumulation rate on the slopes decreases. (2) Ice-wedge architecture within frozen ground allows identifying two generations of Holocene ground ice formation. Near-surface thermal change occurred at 4000 yrs BP creating narrow-meshed ice wedge polygons on top of wide-meshed polygons. (3) Pore ice oxygen isotope signatures reveal that the regional Holocene Thermal Maximum happened at about 9000 yrs BP. (4) The crater undergoes a principal lake level drop in Late Quaternary time. Age determination of pebble bars that surround the lake reveal a minimum age of 13,000 yr BP for the ancient shorelines. Dating is based on analysis of a permafrost core that was extracted behind the raised bars, where slope deposits have accumulated after the bar formation. (5) Mineralogical ratios (quartz to feldspar) and single quartz grain micromorphology have been tested on Holocene frozen ground deposits as proxy data reflecting the strength of cryogenic weathering. The selective cryogenic break-up of grains is particularly related to thaw and freeze dynamics in the active layer. When applied to the lake sediments the mineralogical data illustrate the persistence of cryogenic weathering at least back to about 300,000 yrs BP, the time that is covered by first lake sediment cores.

Future ICDP deep drillings into the permafrost and the lake will enable to extend knowledge about permafrost changes back into time. Presumably, this will cover the Pliocene/Pleistocene boundary when northern hemispheric glaciations started to intensify and the onset of permafrost formation can be dated.

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SURFACE AND DEEP WATER MASSES IN THE ARCTIC OCEAN IN THE LAST 250 KY

Robert F. Spielhagen^{1,2}, Martin Frank², Brian A. Haley², Niels Nørgaard-Pedersen³, Leonid Polyak⁴

¹ Mainz Academy of Sciences, Humanities and Literature

² Leibniz-Institute of Marine Sciences, IFM-GEOMAR, Kiel

³ GEUS, Copenhagen

⁴ Byrd Polar Research Center, Columbus

A close relationship is noted for the variability of water masses and ice cover in the Arctic Ocean and the history of waxing and waning ice sheets on the Eurasian continent in the last 250,000 years. In this presentation we will analyze the role of the Arctic Ocean which has been a passive and active player under different climatic conditions. Microfossil and sedimentological data, oxygen and carbon isotope records from both planktic and benthic foraminifers, and neodymium isotope ratios from authigenic precipitates on lithogenic particles are used to investigate the complex relationship of oceanic and terrestrial developments. In addition to the published records from the Eurasian Arctic and the Lomonosov Ridge (Spielhagen et al., 2004; Nørgaard-Pedersen et al., 2007; Haley et al., 2008), we utilize also previously published records from the Amerasian Arctic Basin, for which we have partly applied an improved and adjusted age model. The results indicate that seasonally open water areas during warmer periods allowed for increased evaporation which facilitated the moisture supply for the initiation of ice sheets. In glacial periods like the marine isotope (sub)stages (MIS) 6, 5b, and 4-3, ice sheets reached the continental margins and the ocean and strongly influenced the oceanic environment. Sedimentological data indicate large numbers of icebergs in the Arctic Ocean, reaching far into the Amerasian Basin. The high-resolution Nd isotope data from the Lomonosov Ridge suggest that cooling and sea ice formation at the ice sheet fringes along the northern Eurasian continental margin played a dominant role in the formation of dense water masses which then spread as intermediate waters in the Arctic Ocean. However, in warmer periods this layer was, like today, composed mostly of water masses with a North Atlantic origin. That source was also dominant in MIS 2 and most of MIS3 – a fact which might support the model of a non-glaciated northern Kara Sea during these times. At glacial terminations large amounts of freshwater and glacier ice were released from the decay of ice sheets and the discharge of ice-dammed lakes on the Eurasian continent. This resulted in a short breakdown of deepwater ventilation in the Arctic Ocean. The freshwater discharge may even have reached the areas of deepwater renewal in the North Atlantic and contributed to a slowdown of the global thermohaline circulation.

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TIMING OF LATE PLEISTOCENE GLACIATIONS IN THE VERKHUYANSK MOUNTAINS, NE-SIBERIA

Georg Stauch and Frank Lehmkuhl

Department of Geography, RWTH Aachen University, Templergraben 55, 52056 Aachen, Germany

The Verkhoyansk Mountains are located at the eastern border of northeastern Siberia between 62° and 72°N. The recent climate is extremely continental with an annual temperature range of up to 100°K on the eastern side. Precipitation in the area is mainly controlled by cyclones which come from the Atlantic Ocean and cross the nearly the entire Eurasian continent. Precipitation values in the Verkhoyansk Mountains therefore show large differences between the eastern and the western side of the mountain system. During Pleistocene cold phases the climate in northeastern Siberia should have been affected by an even higher degree of continentality. Furthermore, continental ice sheets in northern Europe as well as in western Siberia should have had a strong influence on precipitation values in the area. Reconstructed Pleistocene glaciations in the Verkhoyansk Mountains therefore should mirror these changes. However, only little information on Pleistocene glaciations in the Verkhoyansk Mountains are available and they are hampered by poor dating results. All absolute ages on glacial deposits in the area are based on radiocarbon ages from the 60th to early 80th (e.g. Kind et al 1971, Kind 1975, Kolpakov & Belova 1980). According to these reconstructions the largest glaciation during the last 120ka occurred during the early part of last glacial cycle (Zhigansk in the local stratigraphy). A second glaciation should have been taking place around 30ka during interstadial times and reached nearly the extend of the previous one. It is unique in the Verkhoyansk Mountains and cannot be found in any neighboring area. The glaciation during the global last glacial maximum (gLGM; Sartan) was considerably smaller in size. However, glaciers still attained length of more than 120km of length and formed large terminal moraines in the western foreland of the mountains.

New IRSL dates which have been obtained from aeolian and glaciofluvial material in two catchment areas (Tumara R. and Djaunshka R.) on the western side of the Verkhoyansk Mountains during the 2002 and 2003 indicate a different timing of the late Pleistocene glacial advances (Stauch et al 2007). Five sets of terminal moraines (I to V) have been mapped during two field seasons and by the use of remote sensing data. According to these results the last glacial advance in the area is older than 50ka. Terminal moraines related with this advance can be found inside of the Mountains far upstream of the foreland. Terminal moraine II has been deposited at the mountain front. Aeolian sediments on top of the till have an age of 46.8 ± 3.7 ka (V17; Stauch et al. 2007). According to the stratigraphic position of the sediments the glacial advance should be older. The large terminal moraine in the foreland has been attributed to a third glacial advance (III) and has been formed according to the IRSL ages before 80ka. Moraine IV and V have been heavily destroyed by fluvial and glaciofluvial activity related to the younger glacial advances. Moraine IV is older than 100ka while moraine V has been dated to 135 to 140 ka. This later one should belong to the previous glacial cycle, however no interglacial deposits have been found up to now.

The timing of the late Pleistocene glaciation in the Verkhoyansk Mountains is comparable to the evolution of the Eurasian ice sheet (see Svendsen et al. 2004 and references there) and in the Putorana Mountains (Astakhov & Mangerud 2007).

The results point to extremely dry conditions in the Verkhoyansk mountains during the gLGM which prevented glacial advances in the area. Precipitation was shielded by the large European sector of the Eurasian ice sheet, which were becoming large through the course of the last glacial cycle. The eastern sector of the Eurasian ice sheet had an opposite signature which is roughly comparable to the development in the Verkhoyansk Mountains. However, in the study area the climate was even more extreme.

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EPISODIC ICE STREAMING INTO THE ARCTIC OCEAN FROM THE NORTH-WESTERN MARGIN OF THE LAURENTIDE ICE SHEET

Chris R. Stokes¹, Chris D. Clark² and Robert Storrar³

¹Department of Geography, University of Durham, Durham, DH1 2HD, UK

²Department of Geography, University of Sheffield, Sheffield, S10 2TN, UK

³Department of Geography, Royal Holloway, University of London, Egham, TW20 0EX, UK

Victoria Island lies at the north-western limit of the Laurentide Ice Sheet in the Canadian Arctic Archipelago and possesses an abundance of glacial landforms including numerous cross-cutting lineation patterns. Previous work suggests that several ice streams operated in this region during the last Wisconsinan glaciation and that they played a major role in ice sheet dynamics and the delivery of icebergs into the Arctic Ocean. Utilising a new glacial geomorphological map of Victoria Island and a previously published radiocarbon-based margin chronology, the aim of this paper is to produce the first detailed synthesis of ice stream behaviour in this region from 18 to 8.5 ¹⁴C ka BP (21.4 to 9.5 cal ka BP). A glacial inversion method is used to identify and classify over 70 discrete flow-sets (individual ice flow events) which are then 'fitted' to the ice margin configuration constrained by radiocarbon dating. Several ice streams are identified which range in size from huge ice streams that operated for several thousand years to much smaller 'deglacial' ice streams that probably only operated for a few hundred years. Our reconstruction depicts major ice streams in M'Clure Strait and Amundsen Gulf which underwent relatively rapid retreat from the continental shelf edge between 12.5 and 12 ¹⁴C ka BP: a period of climatic amelioration and rapid sea level rise (meltwater pulse-1a). Following this, retreat was slowed and the ice streams exhibited contrasting behaviour. The Amundsen Gulf Ice Stream continued to operate during ice margin withdrawal, whereas the M'Clure Strait Ice Stream ceased operating and was replaced by an ice divide (in probably less than 1000 years). This ice divide was subsequently obliterated by another short-lived phase of ice streaming in M'Clintock Channel soon after 11 ¹⁴C ka BP. This timing of this iceberg discharge event coincides with the onset of the Younger Dryas. Following this event, a minor ice divide developed once again in M'Clintock Channel, before final deglaciation of the island shortly after 9 ¹⁴C ka BP. We conclude that large ice streams at the NW margin of the LIS (equivalent in size to the Hudson Strait Ice Stream) underwent binge-purge oscillations and indicate non-steady delivery of icebergs into the Arctic Ocean. Published radiocarbon dates constrain this punctuated delivery, as far as is possible within limits imposed by their precision, and we note their coincidence with pulses of meltwater delivery inferred from numerical modelling and ocean sediment cores.

CLIMATE AND ENVIRONMENTAL VARIABILITY IN CENTRAL YAKUTIA DURING THE LATE PLEISTOCENE AND HOLOCENE: NEW PALEOLIMNOLOGICAL DATA

Dmitry Subetto¹, Bernhard Diekmann², Lyudmila Pestryakova³, Andrey Andreev², Margarita Gerasimova³, Steffan Popp², Larisa Nazarova², Katarzhina Stakhura-Sukhoples², Hermann Lüpfer²

¹Herzen State Pedagogical University, St.Petersburg, Russia

²Alfred Wegener Institute for Polar and Marine Research, Potsdam, Germany

³Yakutian State University, Yakutsk, Russia

Central Yakutia is part of the world with extreme climate and environmental conditions (air temperatures vary from $-63\text{ }^{\circ}\text{C}$ in January to $+38\text{ }^{\circ}\text{C}$ in July; annual precipitation is ca 200 - 250 mm; the mean annual number of days of freezing temperatures is 205; the annual evaporation is approximately 350 mm to 400 mm; lakes are frozen for most of the year up to 240 days). In contrast to Europe and North America, extended ice sheets were absent during the last climatic glacial-interglacial cycles. The lacustrine sediment records provide insights into environmental dynamics of the late glacial to Holocene period at high temporal resolution.

In the frame of the Russian-German scientific projects "SibLake" several lakes have been paleolimnologically studied in Central Yakutia. The study of Holocene climate and environmental variability is concentrated on long sediment cores taken with Russian corer and piston-coring techniques from lakes around Yakutsk, Lake Satagay (Vilyuy area), and Lake Billyakh (Verkhoyansk Mountains). Several long sediment cores from Lake Billyakh ($65^{\circ}17'\text{N}$, $126^{\circ}45'\text{E}$, 340 m a.s.l.) in the Verkhoyansk Mountains were retrieved in spring 2005 (Diekmann et al., 2007). The 10x3 km big and up to 25 m deep lake is of tectonic origin and was sculptured by glacial advances of mountain glaciers prior to 40 ka BP. In summary, a total of 35 m sediment cores was taken. In the central part of Lake Billyakh, five sediment cores were taken from Site PG1755 at 7.8 m water depth. The overlapping cores provide a 9.4 m long sediment section, dominated by green-greyish silty clays that are partly laminated. The upper 1.5 m of the sediment sequence is characterized by relatively high concentration of fine-grained organic matter in the clastic muds. The first radiocarbon dates indicate a Holocene age of the upper section. The lower part possibly spans the time down to at least 30 ka BP. Granulometric and mineralogical characteristics point to a high contribution of aeolian dust into the lake sediments around 30 ka BP, consistent with the widespread formation of loess-like sediments in the catchment area of the lake. Ongoing studies deal with diatom and pollen records of the - for Yakutia - unique late Pleistocene section.

Table. Radiocarbon dates from cores PG1755 and PG1756, Lake Billyakh.

Core	Depth (m)	Radiocarbon Age (yr BP)	Cal. Age (yr BP)
PG1755-2	1.33	9450±40	10677±56
PG1755-4	3.97	>20000	
PG1755-4	5.32	27220±200	
PG1756-2	0.9	1145±40	1065±62
PG1756-3	2.14	4400±300	4998±398
PG1756-3	4.1	11105±60	13002±119

Another sediment record from a shallow thermokarst lake, covering the last 7 kyr at high temporal resolution, is available from Lake Satagay, situated close to the northern treeline limit ($64^{\circ}28'$, $122^{\circ}43'\text{E}$, 175 m a.s.l.). The 11 m long sediment record reveals centennial climate oscillations in lake level, especially for the time interval of the mid-Holocene climate transition (7.0-4.5 ka BP) (Popp, 2007). The lake status record reveals a long-term trend towards lake-level lowering in the

course of climate deterioration after 4,2 ka BP and reduced evaporation as well as progressive sediment infill. The long-term trend is overprinted by short-term fluctuations with high water-levels and decreased biological influx during with cool climate spells and reduced evaporation. The short-term climate spells appear at roughly 350-year cycles and reveal affinities to long-term fluctuations in solar activity.

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A LAKE CORING CAMPAIGN IN THE POLAR URALS – RESULTS AND PLANS

John Inge Svendsen

Department of Earth Science, University of Bergen, Norway

The overall aim of the Russian-Norwegian project Ice Age Development and Human Settlement in Northern Eurasia (ICEHUS) is to improve the description and understanding of the Late Quaternary environmental changes in the Russian Arctic and how these changes may have affected the early human occupation. Some key findings during the foregoing QUEEN program were that the Barents-Kara Ice Sheet inundated the mainland several times during some early stages (MIS 5a and MIS 4) of the last Ice Age, but that most of the Russian Arctic remained ice free during the last major glaciation (MIS 2). It also became clear that ice age humans had crossed the Polar Circle not later than 40 ka, which is much earlier than previously thought. Furthermore, the archaeological finds demonstrate that humans colonized the northern landscapes several times during the last Ice Age, but it is not yet clear to what extent these migrations are related to climatic changes or other factors. We are now testing some of the QUEEN hypothesis following three lines of actions: 1) investigations of exposed strata and archaeological sites, 2) cosmogenic isotope dating of erratic boulders and 3) coring of lake basins. So far the ongoing investigations have not falsified the main conclusions that were drawn by the QUEEN community, but it seems clear that some of the reconstructed ice sheet limits needs some revisions. However, we realize that our understanding of the glacial history and past climatic changes in the Arctic is hampered by the lack of continuous palaeoenvironmental records covering long time spans. As a matter of fact, in northern Russia there are no such records that date back to the last interglacial. It should also be taken into account that the glacial chronology on land to a large extent relies on OSL dates, a method that is still associated with significant sources of errors and there are quite a few contradicting results. In order to test present hypothesis and extend the record of climate variability it is desirable to core lake basins that may provide long and continuous climate archives. A main activity in the ICEHUS project will therefore be to core lake basins in the Ural Mountains which according to our hypothesis may possibly date back to the last interglacial. One of our main targets is Bol. Shuchye, a 140 m deep lake situated in the Polar Urals. Seismic profiles show that this lake basin contain more than 35 m of fine grained sediments and there is all reason to believe that the mapped strata represent a long-lasting period. Some short cores have been retrieved from the lake floor and next year it is planned to core the entire sequence. We have also cored two other lakes in the Polar Urals that we hope will help us to unravel the climate and glacial history of this region.

THE COLLAPSE OF THE MAMMOTH STEPPE ECOSYSTEM

Thijs van Kolfschoten

Faculty of Archaeology, Leiden University

During the Late Pleistocene the environment of the northern territories of Eurasia, ranging from Western Europe to Alaska, was generally open, tending toward steppic. It is known as the Mammoth Steppe, a biotope remarkable for its unusual combination of mammal species when compared to the present-day distribution. The ecosystem of the Mammoth Steppe collapsed during the period that marks the Pleistocene – Holocene transition and was replaced by the modern tundra, taiga, and steppe belts of Eurasia. The Mammoth Steppe was very productive and characterised by a very diverse flora and fauna with a large variety in species. During the Pleistocene – Holocene transition a drastic rearrangement of its floral and faunal components occurred and led to a marked change in the distribution of species. The geographical ranges of several species shrank and many became regionally extinct, whereas others disappeared completely. It was the time when species such as giant deer, woolly mammoth, and woolly rhinoceros became extinct after having survived many climatic changes during several hundreds of thousands of years. It is also the period during which humans spread into Northern Siberia and crossed Beringia on their way to America.

A Russian-Dutch team started recently a project that will focus on the collapse or disintegration of the Mammoth Steppe ecosystem at the level of faunal assemblages as well as at species level. Our goal is to create a database and analyse the faunal data (particularly mammalian data) that characterise the Mammoth Steppe environment using well (^{14}C) dated faunas from the time span ranging from 40,000 to 8,000 years ago collected in the arctic region north of approximately 60°N latitude. The European data base, the result of the previous joint Russian-Dutch project, will be extended with data from North American and from Siberia. The Siberian data will be extracted from published articles (mainly in Russian language) and a large number of (unpublished) reports. The Siberian faunas which are not well dated will be dated by ^{14}C in this project.

The extended data base will be analysed in the same way as the European data were before. The time span covered by the project will be subdivided into six different intervals, and the collected data relating to these intervals will be analysed mathematically. The mathematical analyses will yield maps showing the distribution of species and/or characteristic faunal communities for the different time intervals. Comparing these maps will clarify the chronology and dimensions of the changes the ecosystem underwent during the latest Pleistocene and the early Holocene. In addition, regional changes will be investigated in order to understand the processes that led to the collapse of the Mammoth Steppe.

SEA-LEVEL AND ICE SHEET HISTORY OF WEST GREENLAND DURING THE LAST MILLENNIA: WORK IN PROGRESS

Sarah Woodroffe and Antony Long

Department of Geography, Durham University, Science Site, South Road, Durham DH1 3LE, UK.

Ice core and other palaeoenvironmental archives from terrestrial and marine settings record several major climate perturbations during the last millennia in Greenland that include the “Medieval Warm Period” and the “Little Ice Age”. These changes were associated with variations in ice sheet mass balance and associated changes in ice margin position and ice load. For example, in Disko Bugt (West Greenland), the ice sheet margin is thought to have retreated between AD 600 and AD 1300, before readvancing to a maximum position at c. AD 1750 and then retreating to present. In this paper we present a new methodology for reconstructing high resolution records of RSL change from West Greenland, from which we may infer variations in ice sheet mass balance over decadal to centennial time scales. Our challenge has been to minimise age and altitude uncertainties, which are routinely high in conventional RSL approaches in Greenland and other Arctic areas that rely on shell and isolation basin chronologies. To achieve this, we target thin (0.5 m) salt marsh sediment sequences to provide multiple RSL data points based on AMS radiocarbon dating of terrestrial plant macrofossils and a transfer function based water level reconstruction that uses diatoms and other sedimentological criteria. The transfer function has a typical height uncertainty for each data point of +/- 0.2 m, whilst high precision AMS radiocarbon dates reduce age uncertainty to a little as +/-20 years. We present a salt marsh-based RSL records from West Greenland (Sisimiut) that spans the last millennia. Existing models of RSL change during this interval suggest a rise in RSL of up to 8 m since AD 1100. In contrast, our new work indicates a slower and more modest rate of RSL rise during this interval, which at Sisimiut is c. 1.7 mm yr⁻¹ until c.1500 AD, followed by a slowdown in the rate of sea-level rise, with virtually stable sea level at least during the 20th century. New, high resolution RSL records, such as these, provide targets for geophysical models of ice sheet mass balance change and a long term context for short term geodetic records of crustal motions and ice sheet dynamics.

Poster Area C

EVIDENCE OF HOLOCENE CLIMATIC VARIABILITY IN NORTHERN FINNMARK

Judy R.M. Allen¹, Brian Huntley¹, Antony J. Long²

¹School of Biological and Biomedical Sciences, University of Durham, South Road, Durham. DH1 3LE. UK.

²Department of Geography, University of Durham, South Road, Durham. DH1 3LE. UK.

In order to test the hypothesis that the northernmost region of Finnmark experienced centennial to millennial scale climatic variations throughout the Holocene a series of small lakes lying outside the younger Dryas ice limit was investigated.

Investigations focussed on Over Gunnarsfjorden (71.038° N, 28.169° E; 78m asl; cored in late winter 2000) which lies above the marine limit on Nordkinnhalvøya; AMS radiocarbon dates on terrestrial plant macrofossils show that organic sediment accumulation started just prior to 12,500 calibrated years BP (10,580 ¹⁴C years BP). A second site, just 2km west of Over Gunnarsfjorden, Ned Trollhetta (71.041° N, 28.116° E), lies at 167m asl. This lake was also cored in late winter 2000 and a basal AMS radiocarbon date indicates that sediment accumulation started here much earlier - about 15,000 calibrated years BP (12,665 ¹⁴C years BP); outline pollen analyses indicate significant development of early late-glacial vegetation. Two other sites investigated were Liten Čap'pesjav'ri (71.079°N, 25.360°E; 41m asl) on Magerøya to the west and Over Kobbkrokvatnet (70.699°N, 29.295°E; 51m asl) on Varangerhalvøya to the east; both were cored in late winter 2001.

Pollen analysis at Over Gunnarsfjorden confirmed that the regional vegetation responded to Holocene climatic variability at centennial – millennial time scales. Palaeoclimate reconstructions indicate that marked changes in seasonality characterised these Holocene climatic fluctuations. Intervals with warmer summers, higher temperature sums and higher precipitation, but cooler winters and generally reduced moisture availability, alternated with intervals with cooler summers, lower temperature sums, lower precipitation, warmer winters and greater moisture availability. The former conditions were more prevalent between ca. 8950 and 3950 cal B.P., whereas the latter predominated before ca. 8950 and since ca. 3950 cal B.P. Pollen analyses at the western and eastern sites along the transect also appear to reflect this pattern, although this cannot be confirmed because chronological information at these sites is as yet limited.

Geochemical analyses of the lake sediments at Over Gunnarsfjorden indicated minerogenic material was derived from two or more distinct sources or transport pathways that differed in their responses to palaeoclimatic conditions.

Time-series analyses of pollen analytical and sediment geochemical data indicate that both exhibit statistically significant periodic behaviour (at periods of ca. 190, 410, 1050, 1650 and 1810 yr). The periods detected suggest that this behaviour may reflect the regional expression of responses to solar variability and/or to lunar orbital periodicity and its effects upon tides and ocean circulation. Comparison with records of fluctuations in ocean thermohaline circulation strength indicate some concordance with respect to timing of warmer and cooler intervals, but also some differences.

Poster Area A

THE LITTLE ICE AGE AND GLACIAL ISOSTATIC ADJUSTMENT IN SOUTH-CENTRAL ALASKA

Natasha Barlow, Ian Shennan and Antony Long

Sea Level Research Unit, Department of Geography, Durham University, Durham, DH1 3LE

The Little Ice Age (LIA) is the largest Holocene climate fluctuation to have occurred in the Northern Hemisphere. In Alaska climate deterioration culminated in the late 19th century when temperatures fell to 2°C lower than present day levels and many coastal mountain glaciers advanced to their maximum Holocene position. Subsequent mass balance loss in southern Alaska and British Columbia is estimated to supply over half the contribution to global sea-level from sources outside Greenland and Antarctica during the past 50 years, with a contribution to sea level of $0.27 \pm 0.10 \text{ mm yr}^{-1}$ over the past decade (Ardent *et al.*, 2002). The coastal margins of south-central Alaska therefore provide an excellent context in which to test 'instantaneous' versus 'delayed' models of glacial isostatic response to short-term climate fluctuations and associated ice mass change.

We study spatial variations in isostatic response in the western Chugach Mountains using a transect of salt marshes along Turnagain Arm, Upper Cook Inlet. Litho- and bio-stratigraphic analysis of coastal sediments establishes the tendencies of sea level change with the development of appropriate transfer functions furthering quantitative reconstruction. Previous work (Hamilton and Shennan, 2005) has quantified the tectonic component of RSL change in this region; though additional methods need to be employed to help constrain the isostatic factor in this geologically complex setting. The application of a flat earth model combined with detailed ice chronologies will further predictions of LIA RSL changes in both space and time. A challenge of this work is to develop high precision RSL records. We aim to address this issue by combining AMS radiocarbon dating, tephrochronology, pollutant records and ¹³⁷Cs and ²¹⁰Pb profiles.

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Poster Area C

A PRELIMINARY INVESTIGATION OF COCCOLITH DISTRIBUTION AND CARBONATE SEDIMENTATION IN HOLOCENE SEDIMENTARY CORES OF THE WEST SPITSBERGEN MARGIN (WARMPAST PROJECT/IPY 786)

Jacques Giraudeau¹, Katrine Husum², Anne de Vernal³, Robert Spielhagen⁴ and Morten Hald²

¹Université Bordeaux 1 – UMR CNRS 5805 EPOC, Avenue des Facultés, 33405 Talence, France;

²Dept of Geology, University of Tromsø, Norway;

³GEOTOP – UQAM-McGill, Montréal, Canada; Leibniz-Institut für Meereswissenschaften, IFM-GEOMAR, Kiel, Germany.

The sensibility of the marine biosphere to changes in local physic-chemical characteristics of the northern North Atlantic has been evidenced in the last decades by in-situ or remote sensing observations. Both are indicative of biogeographical shifts of plankton biodiversity and drastic modifications in phytoplankton community (e.g. coccolithophore blooms in the northern Nordic Seas). These changes are thought to reflect modifications in the stratification and temperature of the water column linked with freshening of the northern ocean induced by sea-ice melting and increased surficial temperature due to increased northward inflow of Atlantic waters. The West Spitsbergen Current (WSC) constitutes the main conduit for Atlantic waters entering the Arctic Ocean. While the climatic history of the present interglacial in the northern high latitudes have shown that rapid climate changes have occurred repeatedly throughout the last 10000 years, additional information is needed to assess the mechanisms involved into these changes. Marine sedimentary records from the Fram Strait area are ideally located to evaluate the past intensity of Atlantic water inflow into the Arctic domain and implications on the sea-ice extension and on reorganization of the thermohaline structure and dynamics.

Marine cores recently retrieved from the west Spitsbergen margin within the framework of the IPY *Warmpast* project (cruise JM06) are investigated in the present study to assess patterns of variability in sedimentation of bulk biogenic carbonates and of fossil remains of calcareous phytoplankton (coccoliths) throughout the Holocene. Our preliminary stratigraphical framework suggests that the investigated cores accumulated at a relatively high rate (ca. 1cm/50 yrs) and are therefore well suited for a high resolution study of the Holocene time period. Our combined geochemical and micropaleontological data are indicative of rapid changes in the Holocene dynamics of the WSC; this will be discussed in view of accompanying Holocene records from arctic and subarctic areas presently bathed by various branches of the poleward Atlantic water flow.

Poster Area A

A HIGH RESOLUTION LATE GLACIAL AND POSTGLACIAL RECORD FROM THE CENTRAL LOMONOSOV RIDGE, ARCTIC OCEAN

Daniela Hanslik¹, Martin Jakobsson¹, Svante Björck² and Göran Skog³

¹Department of Geology and Geochemistry, Stockholm University, Sweden

²GeoBiosphere Science Centre, Department of Geology, Quaternary Science, Lund University, Sweden

³Radiocarbon Dating Laboratory, Department of Geology, Quaternary Science, Lund University, Sweden

Core HLY0503-18TC used for this study was taken during the 2005 Healy-Oden Trans-Arctic Expedition (HOTRAX) on the central Lomonosov Ridge. The coring site is located in a local "Intra Basin", a >1000 m deep depression in the ridge morphology, where sedimentation appears to be focused and accumulation rates, thus, are higher (Björck et al., 2007). The uppermost 70 cm of core HLY0503-18TC contains high abundances of well preserved planktonic and benthic foraminifera and calcareous nannofossils. The planktonic foraminifera assemblage in the >125 μm size fraction is monospecific and consists of *Neogloboquadrina pachyderma*, of which >95% are of the left-coiling variety. Stable isotope measurements of the >150 μm size fraction on *N. pachyderma* (s) show a distinct $\delta^{13}\text{C}$ minimum at 35-40 cm depth. Similar changes in $\delta^{13}\text{C}$ in previous studies have been associated with a major melt water anomaly at the beginning of Termination I (Nørgaard-Pedersen et al., 1998; Stein et al., 1994). We also see other signs for a significant shift at this depth, such as low foraminifera abundance and a change in the coccolith assemblage (Fornaciari et al., 2006). To establish an age model for core HLY0503-18TC radiocarbon dating was performed on nine very small planktonic and benthic foraminifera samples at Lund University Radiocarbon Dating Laboratory. The results indicate Holocene/Late Glacial ages for the samples in the upper half of the core. The oldest non-infinite ^{14}C -dating provided an age of ~14 cal ka BP on a sample at 32 cm depth (Marine04 calibration data set). However, the highly incoherent ages of planktonic and benthic foraminifer at 12 cm depth imply high reservoir ages for at least deeper Arctic waters, showing that caution is needed when a ^{14}C based chronology is established on Arctic marine sediments. All ^{14}C measurements below 42 cm core depth yielded infinite ages (>44 ka). This large shift of more than 30 kyr over a few centimeters suggests a hiatus, either in form of no/low sedimentation or erosion due to changes in the paths or strength of the bottom currents. The abundance of foraminifera and the nannofossil composition of the sediments between 40 and 70 cm core depth suggests that this part of the core belongs to either marine isotope stage 3 or 5 (Fornaciari et al., 2006). This implies that at least entire MIS 2 may be missing in the core.

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Poster Area C

THE PENULTIMATE INTERGLACIAL-GLACIAL CYCLE (MIS 7-6) IN THE RUSSIAN ARCTIC - EVIDENCE FROM EXPOSED STRATA ALONG THE RIVER SEYDA

Mona Henriksen¹, Valery Astakhov², Jan Mangerud³ and John Inge Svendsen³

¹Department of Plant and Environmental Sciences, Norwegian University of Life Sciences, 1432 Ås, Norway

²Geological Faculty, St. Petersburg University, St. Petersburg 199034, Russian Federation

³Department of Earth Science, University of Bergen, 5007 Bergen, Norway

We have investigated a 50 m high bluff cut by the Seyda River located in the Pechora Lowland, NE European Russia. In the lowermost part the section is a clayey, matrix-supported till, rich in gravel and boulders. Overlaying this till is an interglacial unit dated to around 200 ka (MIS 7) by OSL and U/Th, consisting of an up to 1 m thick peat, as well as sand and silt. Pollen analyses suggest conditions warmer than today. Both the peat and the sand are glaciotectonically deformed, most likely by the same glacier that deposited the overlying 15-22 m thick till. This till is a brown-grey matrix-supported diamicton, sandier than the lower till and not so boulder-rich. In the lower part fabric indicates ice-flow from NW, turning towards NE in the uppermost part. Above the till is fluvial gravel and sand which are folded and sheared from NE. No till is found above, but there are boulders at the surface implying a former till. The sand is dated to c. 160 ka implying that all units between this and the interglacial sediments belong to the same glaciation. The gravel and sand accumulated in a meltwater river close to the ice margin. Subsequently the glacier advanced over the glaciofluvial sediments deforming them, suggesting an active retreat of the Barents-Kara ice sheet during the Late Moscowian (MIS 6) for c. 160.000 years ago.

Close by is the Rogovaya Moraine, a c. 150 km long and narrow lobe trending NE-SW. It is constrain in the Rogovaya River valley and the crest of the lateral moraine descends only about 50 m long these 150 km. A couple of the ridges bend concavely towards the centre of the valley giving the moraine system a long, narrow loop-shape. These features suggest deposition by a thin and almost flat ice lobe from the Barents-Kara Ice Sheet along an active, retreating ice margin. Given that the upper till at Seyda also suggest an active, retreating glacier, the Rogovaya Moraine may be of the same age, i.e. Late Moscowian. However, we cannot exclude a Valdaian age of Rogovaya Moraine, although it has to predate the glacial Lake Komi, c. 90 ka.

Poster Area C

LATE HOLOCENE CHANGES IN OCEAN CIRCULATION AND CLIMATE: MULTI-PROXY EVIDENCE FROM KONGSFJORDRENNEN, WESTERN SVALBARD

S. E. MacLachlan¹, J. A. Howe², W. E. N. Austin³ and T. Shimmield²

¹National Oceanographic Centre, European Way, Southampton, SO14 3ZH, UK

²Scottish Association for Marine Science, Dunstaffnage Marine Laboratory, Oban, Argyll, PA37 1QA, UK

³School of Geography and Geosciences, University of St Andrews, Fife, KA16 9AL, UK

A 260 cm long sediment core spanning the last 5870 years was collected from Kongsfjordrenna, western Svalbard, in 342 m water depth. Detailed analyses of stable isotopes, benthic foraminifera, geochemical and lithology was performed on the core, and a geochronology based on four AMS radiocarbon dates combined with core top ²¹⁰Pb chronology. The benthic fauna is dominated by species typical of the Arctic continental margin. Calcareous species of foraminifera, such as *Cassidulina reniforme*, *Elphidium excavatum* and *Nonion labradoricum* dominate the core. High latitude glacial conditions are characterised by low abundances and low diversity of benthic foraminifera, common characteristics displayed by the fauna in the core. Down core variations in the oxygen isotope ratios in the benthic species *Cibicides lobatulus* in Kongsfjordrenna are interpreted to reflect temperature variations with a maximum amplitude of ~ 3 °C. A rising sedimentation rate and proxy data indicate increased glaciation from ~ 2500 yrs BP, probably in response to the late Holocene cooling; culminating in two glacial maxima within the late Holocene at ~1800 yrs BP and the most recent corresponding to the 'Little Ice Age' (~315 yrs BP). These periods are characterised by 1.5-2 °C reduction in the bottom water temperatures in Kongsfjordrenna. The fluctuations in the record of glacial conditions are contemporaneous with the Holocene ice-rafting events in the North Atlantic and glacier fluctuations of Northwestern Europe. This implies that late Holocene climate variation in western Svalbard are triggered by circulation changes in the North Atlantic region.

Poster Area A

DISTRIBUTION OF “SMALL” PLANKTONIC FORAMINIFERA IN NORTHERN HIGH-LATITUDE OCEANS: IMPROVING RECONSTRUCTIONS OF SEA SURFACE TEMPERATURES

Katrine Husum¹, Morten Hald¹ and Anne Burhol¹

¹Department of Geology, University of Tromsø, Dramsveien 201, N-9037 Tromsø, Norway

In order to investigate natural rapid ocean changes on longer time scales it is crucial to obtain reliable quantitative proxy data. Earlier reconstructions of sea surface temperatures (SST) in northern high-latitude oceans (below 5°C) are hampered by incomplete training sets, sample quality and unsuitable sample preparation techniques. The aim of this study is to obtain surface samples with undisturbed sediment-water interface and correlate modern planktonic foraminifera with in situ measurements of environmental parameters e.g. sea-ice distribution, temperature and salinity. It is also an aim to test different transfer functions in order to identify the best suitable statistical method for reconstruction of quantitative ocean temperatures. Depth habitats of planktonic foraminifera are variable, and they do not always reflect the upper most surface temperature. This should be taken into account when correlating to environmental parameters and later reconstructing temperatures. The studied size fractions of planktonic foraminifera are also a critical factor. Many studies have investigated the fraction larger than 125 and 150 µm. This may reduce the faunal diversity to near monospecific assemblages and much vital fauna information is left out of the SST reconstructions. Surface sediment samples from the Fram Strait, Greenland Sea and Barents Sea were retrieved using a multicorer/boxcorer and prepared at the size fractions 0.1 – 1.0 mm. The foraminiferal analyses show how *N. pachyderma* (sin) constitutes 96 - 99 % of the fauna in areas under Arctic and Polar surface water masses. Under Atlantic surface water masses *N. pachyderma* (sin) is reduced with up to 50 %, and other species take over e.g. *T. quinqueloba* and *G. uvula*. In addition to planktonic foraminifera other proxies are being investigated as part of the WARMPAST and SciencePub IPY-projects: benthic foraminifera, coccoliths, diatoms, dinocysts, foraminiferal Ca/Mg-ratios and oxygen and carbon isotopes.

Poster Area C

TOWARDS A REVISED STRATIGRAPHY FOR THE KAPP EKHOLM SECTION, BILLEFJORDEN, SVALBARD

Maria Jensen¹, Lena Håkansson², and Anne Hormes³

¹Geological Survey of Norway, N-7491 Trondheim, Norway

²Lund University, Dept of Geology, Sölvegatan 12, S-223 62 Lund, Sweden

³UNIS, P.O. 156, N-9171 Longyearbyen, Norway

The coastal section at Kapp Ekholm in Billefjorden is a key locality for the Quaternary stratigraphy of Svalbard and forms the backbone for the often-used glaciation curve for the western Barents Sea (Mangerud et al., 1998; Svendsen et al., 2004). Earlier work suggests that this is the only locality in Svalbard with evidence of four successive glaciations and intervening marine intervals found in superposition (Mangerud & Svendsen 1992). Previous studies have disagreed on the correlation of units across the ravines cutting through the section. Correlation is complicated further by the lateral variation in sedimentary characteristics within the glacial units and the repetitive pattern of sedimentary facies. Despite the complex nature of the glacial deposits no detailed investigations of their sedimentology have been carried out previously.

This study presents a reinvestigation of the Kapp Ekholm section based on fieldwork carried out in the summer of 2007. Our work is concentrated on the central part of the section where most previous investigations have disagreed on interpretation and correlation of units (sections III, IV og V in Mangerud & Svendsen, 1992). The present study focuses on detailed sedimentological descriptions of the glacial deposits in order to interpret the depositional environment and aims at testing whether all these units are deposited as basal tills as suggested by Mangerud and Svendsen (1992). Correct interpretation of these diamict deposits will have significant implications for reconstructing the magnitude of ice advances in the Billefjorden area and thus also for the understanding of the regional glaciation history.

Detailed sedimentological logs have been measured from sections III, IV and V at Kapp Ekholm. Sedimentological descriptions, clast morphology, clast fabric and grain size analyses of the diamict units are used to distinguish between depositional environments. The sedimentary units have been traced laterally and measurements on deformation structures have been used to determine whether deposition was associated with actively moving ice. The present study confirms a fluctuation between glacial and marine phases as suggested in previous studies, but do not recognize the unit definitions and boundaries described previously. We present the new results and discuss the implications for the glaciation history of Svalbard.

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Poster Area A

MICROMORPHOLOGICAL CHARACTERISTICS OF HIGH-LATITUDE GLACIMARINE SEDIMENTS: CONSTRAINTS ON THE INTERPRETATION OF PLEISTOCENE GLACIGENIC DIAMICTS

Aoibheann A. Kilfeather¹, Colm Ó Cofaigh¹, Julian A. Dowdeswell² and David J.A. Evans¹

¹ Department of Geography Durham University, Durham DH1 3LE

² Scott Polar Research Institute, University of Cambridge, Cambridge CB2 1ER

Samples of known genetic origin were collected for micromorphological analysis from a range of glacimarine depositional environments including the continental shelf and trough-mouth fan offshore of Scoresby Sund, East Greenland, the Bear Island Trough mouth fan on the Norwegian margin, and the Antarctic Peninsula continental shelf. The samples comprised examples of debris flow deposits (from the trough mouth fans), suspension settling (Antarctic Peninsula) and iceberg turbate (East Greenland shelf). In each case the depositional origin of the sediments is constrained by independent evidence in the form of high resolution multibeam swath bathymetry, sub-bottom profiler records and core macro-sedimentology. Structures in thin section from the debris flow sediments include well developed clay and silt coatings on sand and pebble grains; the suspension sediments are largely massive and fine grained with occasional poorly sorted bands; and iceberg turbate sediments contain poorly defined rotational structures and better defined lineations and a strong apparent grain fabric. Such glacimarine samples contrast micromorphologically with sediments formed through subglacial deformation of pre-existing glacimarine sediments (tills). The latter are characterised by structures indicative of pervasive deformation such as crushed grains, and well developed turbates and lineations (Carr, 2001, Ó Cofaigh et al. 2005). The glacimarine samples described here were used as a basis for the interpretation of thin sections of Late Pleistocene "Irish Sea Till" from NE and Eastern Ireland. The Irish Sea Till is a matrix-rich, muddy diamict facies, containing shell fragments, that has been variously interpreted as a subglacial till associated with a grounded Irish Sea Glacier or in-situ glacimarine deposit. This poster presents the results of this study, characterising firstly the micromorphology of the glacimarine samples and then using them as a basis for interpretation of the Late Pleistocene Irish Sea Till.

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Poster Area C

EVOLUTION OF MARINE ENVIRONMENTS IN THE LAPTEV SEA DURING THE LAST SEA LEVEL RISE

Tatiana Klyuvitkina¹, Yelena Polyakova¹, **Henning Bauch**^{2,3} and Heidemarie Kassens³

¹ Lomonosov Moscow State University

² Mainz Academy of Sciences, Humanities and Literature, Germany

³ Leibnitz Institute for Marine Sciences IFM-GEOMAR, Kiel, Germany

The Laptev Sea located in the central part of the Eurasian segment of the Arctic region plays a key role in the formation of the ice and hydrological regime of the Arctic Ocean owing to the intense river runoff during the summer season and formation of ice in the polynya in winter. Thus, the study of the recent and past hydrological processes in the Laptev Sea is of importance for understanding formation of water masses and their evolution in the Arctic Ocean.

We carried out investigations of recent and fossil aquatic palynomorph assemblages from the Laptev Sea sediments dating back to approximately 17.5 cal. ka.

According to data of M. Kunz-Pirrung (1998, 2001) distribution of main aquatic palynomorph groups from the surface sediments clearly reflect the strong salinity gradient in the surface waters of the Laptev Sea.

For the goal of reliable reconstruction of paleo conditions in the Laptev Sea we used CD-ratio – is ratio between freshwater chlorophyte algae and marine dinoflagellate cysts. In the surface sediments of the Laptev Sea CD-ratio values decreased from the coast to the shelf break. It is in a good accordance with the modern surface water salinity and submarine valleys of the main rivers. Thus, CD-ratio can be used as indicator of riverine outflow to the Laptev Sea shelf.

AH-ratio is ratio between autotrophic species of dinoflagellate cyst and heterotrophic ones. Distribution of AH-ratio values in the surface waters of the Laptev Sea good correlates with salinity gradient and reflect the inflow of relatively warm Atlantic waters. Therefore, AH-ratio can be used as indicator of inflow of Atlantic waters to the Laptev Sea shelf and continental slope.

As a result of postglacial sea level rise the shallow Laptev Sea was rapidly flooded. During the Early to Middle Holocene the sea level raised from approximately -50 m to the modern position of the coastline. According to changes in the dinoflagellate cysts species composition and values of CD and AH-ratios the following major events in the development of paleoenvironmental conditions were established:

On the Western Laptev Sea continental slope time interval 17.5–13.0 cal. ka was characterized by low concentration of dinocysts on the continental slope and predominance of euryhaline cold-water species *Islandinium minutum*, *I. cezare* and *Brigantedinium simplex*. This period probably was characterized by extremely sea-ice conditions. The first appearance of autotrophic species was marked 13.0 cal. ka.

According to our data the outer western Laptev Sea shelf (60 m depth) was already inundated around 12 cal. ka. but had a strong fluvial-estuarine (Anabar-Khatanga River) imprint until 11.2 cal. ka.

A pronounced changes in dinocyst assemblage composition between 11.2 and 7.0 cal. ka are characterized by a strong increase in total concentration and proportions of Atlantic-water species (e.g. *Operculodinium centrocarpum*) along with the appearance of relatively warm-water indicative species (*Spiniferites elongatus*, cyst of *Pentapharsodinium dalei*) and high values of AH-ratio. This allows us to assume the enhanced influence of warm Atlantic water and relatively warm-water summer temperature. Since 7.0 cal. ka influence of relatively warm Atlantic water in the Laptev Sea strongly decreased. Modern-like conditions were established approximately 7.0 cal. ka.

Eastern Laptev Sea shelf was rapidly inundated between 11.3 and 10.3 cal. ka and paleoenvironmental conditions were characterized by high precipitation of river-loaded matter, primarily riverine plankton. The following time interval 10.3–9.2 cal. ka on the outer shelf was marked by predominance of the Atlantic-water dinocyst species. The high relative abundances of these species as well as appearance of relatively warm-water indicative species and high values of AH-ratio in the outer Laptev Sea shelf was probably caused by enhanced influence of Atlantic-water at the continental margin or decrease in sea ice cover. 8.9–8.5 cal. ka. the shallow inner Laptev Sea shelf was inundated. High abundances of freshwater algae and high CD-ratio values give evidence for zone of marginal filter of Lena river at the time 8.6–8.8 cal. ka. at the depth 32 m. According to our data modern-like environments on the outer eastern Laptev Sea shelf were reached around 8.6 cal. ka, on the inner shelf around 7.4 cal. ka.

Obtained results allowed us to compile final schemes of the development of hydrographical parameters since 17.5 cal. ka to the modern time for Eastern and Western parts of the Laptev Sea and compile maps of the southward retreat of the coastline under the postglacial sea-level rise.

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Poster Area A

SYNCHRONIC RESPONSE OF ARCTIC ICE SHEETS TO GLOBAL CLIMATE DETERIORATION OVER THE LAST 3.5 MA

Jochen Knies¹, **Jens Matthiessen**², Christoph Vogt³, Jan Sverre Laberg⁴, Berit O. Hjelstuen⁵,
Morten Smelror¹, **Eiliv Larsen**¹, Karin Andreassen⁴, Tor Eidvin⁶ and Tore Vorren⁴

¹Geological Survey of Norway

²Alfred Wegener Institute for Polar and Marine Research

³University of Bremen

⁴University of Tromsø

⁵University of Bergen

⁶Norwegian Petroleum Directorate

Here, we report the revised chronostratigraphic and new sedimentological data of various ODP boreholes (Legs 151, 162) in the Atlantic-Arctic gateway region to present a coherent glaciation model for the Barents Sea ice sheet over the past 3.5 Ma. Pulses of IRD during the Northern Hemisphere Glaciation (NHG) at ~2.7 Ma indicate consistency of glacial dynamics of circum-Arctic ice sheets to global climate deterioration. However, large-scale expansion of the Barents Sea ice sheet towards the shelf edge are not evident before ~1.5 Ma. This is inferred not only from IRD pulses but also from a step-wise decrease of Siberian river supplied smectite-rich sediments likely caused by ice-sheet blockade and glacial wedge growth along the northern and western Barents Sea margin. Large-scale glaciation in the Barents Sea occurs since ~1 Ma (Mid-Pleistocene Transition) and repeatedly advanced to the shelf edge at least 7 times thereafter. The timing is inferred from ice grounding on the Yermak Plateau at ~0.9 Ma attributed to a pronounced ice sheet advance or deep-draft icebergs and higher frequencies of gravity-driven mass movements along the western Barents Sea margin associated with glacial growth.

Poster Area B

ICE-MARGINAL PROCESSES, SEDIMENTS AND LANDFORMS AT MOORE GLACIER, NORTHERNMOST GREENLAND

Anders Schomacker¹, **Nicolaj Krog Larsen**², Henriette Linge³

¹University of Iceland, Institute of Earth Sciences, Askja, Sturlugata 7, IS-101 Reykjavík, Iceland

²Lund University, Department of Geology, Quaternary Sciences, Sölvegatan 12, S-223 62 Lund, Sweden

³Department of Earth Science, University of Bergen, Norway

Glacial sedimentary processes and landforms have been explored by remote sensing and field studies at Moore Glacier, north Greenland which is located in one of the most extreme environments on Earth. The Moore Glacier descends from 800 m a.s.l and terminates at sea level in the inner Bliss Bay. The westernmost part of Moore Glacier calves in the permanently sea-ice-covered Bliss Bay and the eastern part terminates on land with a steep, marginal ice cliff. Here, we studied end-moraine formation and deposition of fine-grained proglacial outwash fans. Despite the extreme setting with only little ablation, the marginal area is a very dynamic sedimentary environment. In addition to the investigations at the Moore Glacier terminus, the glacial geomorphology of Bliss Bay was mapped from aerial photographs and QuickBird 2 satellite imagery. An end moraine in Bliss Bay marks the outermost extent of the expanded Moore Glacier. Cosmogenic ¹⁰Be datings of quartz clasts from the end moraine ridge yield an exposure age of 11.2 ± 1.6 ka. Field measurements of glacial striae and the distribution of eskers aid the reconstruction of recessional ice margins of Moore Glacier. However, the timing of marginal positions is unknown, but it is suspected that they relate to the last deglaciation. Cosmogenic exposure dating of erratic boulders may shed light on the timing of glacier advances in Bliss Bay but results are still pending.

Poster Area B

EVIDENCE FROM NORTH GREENLAND OF A LATE WEICHSELIAN ICE SHELF GLACIATION IN THE ARCTIC OCEAN

Nicolaj K. Larsen¹, Svend Funder², Kurt H. Kjær², Henriette Linge³, Per Möller¹, Anders Schomacker⁴ and Jaap J.M. van der Meer⁵

¹Department of Geology, Lund University, Sweden

²Natural History Museum of Denmark, University of Copenhagen, Denmark

³Department of Earth Science, University of Bergen, Norway

⁴Institute of Earth Sciences, University of Iceland, Iceland

⁵Department of Geography, Queen Mary University of London, UK

The presence of an ice shelf in the Arctic Ocean may have an immense influence on the thermohaline circulation and climate system and much recent effort has been engaged into constraining their occurrence during the Late Pleistocene – mainly based on marine studies. An alternative approach is to search along the more than 100 km long and 15 km wide north coast of Greenland, which has an optimal geographical location in order to understand the interaction between the Greenland Ice Sheet, local glaciers and ice caps and a possible grounded part of an ice shelf in the Arctic Ocean. However, due to the inaccessibility the area has largely remained unexplored until the summers 2006-7, where members of the LongTerm project worked along the coastal zone between the Fold Mountains and the Arctic Ocean. Preliminary results show that a large glacial event affected the North coast by the end of the last glaciation and it is envisaged that an expansion of the Inland Ice from the Nares Strait resulted in the formation of a c. 200.000 km² ice shelf in the Arctic Ocean – a type of glaciation, which has usually been thought to be an Antarctic phenomenon. The evidence for an Arctic ice shelf glaciation from the north coast of Greenland where it must have been grounded comprise: 1) directional elements such as glacial striations, stoss-lee shaped boulders and till fabric indicating ice flow from the west towards the east, 2) erratic boulders with a likely source on Ellesmere Island, 3) east-west orientated mega-scale glacial lineations, 4) and raised lacustrine sediments up to 120 m a.s.l. The timing of the event is constrained by OSL and radiocarbon datings and it indicates the presence of a Late Weichselian Arctic ice shelf glaciation ca. 16-12 kyr BP.

Poster Area C

SEDIMENT AND LANDSCAPE SIGNATURES OF ICE-DAMMED LAKES IN NW RUSSIA

Astrid Lyså¹, Maria A. Jensen¹, Eiliv A. Larsen¹, Igor N. Demidov^{2*} and Ola Fredin¹

¹Geological Survey of Norway, NO-7491 Trondheim, Norway

²Russian Academy of Sciences, Karelian Research Centre, Institute of Geology, 11 Pushkinskaya Street, Petrozavodsk 185610, Russia, * Deceased October 2007

Growth and decay of ice sheets resulted in formation of large ice-dammed lakes in Russia at several times during the Weichselian due to blocking of the northward flowing rivers. The variability in time and space of the Scandinavian, Barents Sea and Kara Sea ice sheets has resulted in a complex and ambiguous lake history, leading to somewhat different interpretations in the literature (eg. Mangerud et al. 2004; Svendsen et al. 2004; Larsen et al. 2006). Reconstructions of the ice-dammed lakes are mainly based on ice-sheet configurations, timing and anticipated lake drainage routes. As field investigations have proceeded, some lake sediments and morphological signatures of these former lakes have been found, such as the huge Lake Komi (Astakhov et al. 1999; Mangerud et al. 1999), although the distribution and pass-points still are under debate. An ice sheet centered over the Barents Sea area coalescing with ice over Scandinavia around 60-70 ka (Kjær et al. 2006; Larsen et al. 2006) suggests that an ice-dammed lake was formed in the White Sea basin, south of this ice margin,. Until now, no correlative lake sediments have been demonstrated. New results from field investigations, dates and satellite images from the Vychegda river (Komi region) show sediments and surface morphologies that likely belong to this "White Sea Lake", and maybe also to a younger lake phase. The lake sediment signatures indicate variations in lake levels during deposition, as well as signatures that may be related to final lake drainage. Morphological features like terraces and surface drainage imprints can be related to the lake phases.

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Poster Area C

LAPTEV SEA LEVEL FLUCTUATION AS A FACTOR OF FORMATION OF THE RIVER LENA DELTA DURING HOLOCENE

Alexander Makarov and Prof. Dmitry Yu. Bolshiyarov

Arctic and Antarctic Research Institute, Russian Federation, St. Petersburg, Beringa st.38

Traditionally, researchers distinguish three terraces in the geomorphologic structure of the river Lena delta (Grigoriev, 1993). The 3rd is made up by the ice complex; the 2nd one is constituted by the sands of paleobasin origin and the 1st terrace is formed, essentially, by delta sediments. It is the first terrace of Holocene age that became the object of implemented research. The main objective was to study composition and genesis of this terrace.

The 1st terrace of the river Lena delta was mainly formed as a result of carrying out the large amount of materials by the river. It was constituted from so called “constrative” alluvium. The modern pattern of the river Lena delta started to develop 5 thousand years ago, when due to the rapid rising, the level of Laptev Sea reached its present condition. Gradually, the deltas of Olenekskaya, Tumatskaya, Sardakhskaya and Trofimovskaya channels had been formed and, finally, about one thousand years ago Bykovsk channel was formed – it continues to develop during our days and basically forms the estuary (Korotaev, 1984). This is the concept of formation of contemporary pattern of the river Lena delta with hydrological processes considered as the main factor of development.

Since 1998, a number of research activities have been carried out within the international project “The System of Laptev Sea” in cooperation with German researchers. The information obtained within this project allows adjusting the fixed notions on the point. The modern hydrological process of the river delta forming is being considered in the close connection to geomorphologic composition and Laptev Sea level fluctuation. It is the comprehensive character of research activities that gave a stimulus to occurrence of new scheme of the river Lena delta development.

The geomorphologic structure of the delta during Holocene is extremely complex. It consists of several uneven-aged cones, clearly seen on space photos and also confirmed by dating. Discernment of similar height surfaces of terraces and floodplains is impeded by their multiple-height characteristics, and first if all, by geologic structure. The 1st terrace is composed of sandy deposits and specific sediments, to 90-100% consisting of mossy plant detritus. We have called this deposit fraction the “peaty”, a plant mass, to a different extent beneficiated by sand and silt, in the form of indecomposable green peat-mosses, detritus of other plants and wood remains, deposited in paleobasin, evidenced by horizontal or wavy texture, highlighted and upset by frost penetration. The “peaty” along the islands cuts caused by channels are often and rapidly replaced or interlapped with sand deposits, as well characterized by wavy and horizontally stratified textures. Such deposits are able to be formed only under condition of changes in erosion basis, namely, fluctuation of receiving reservoir (Fig.1).

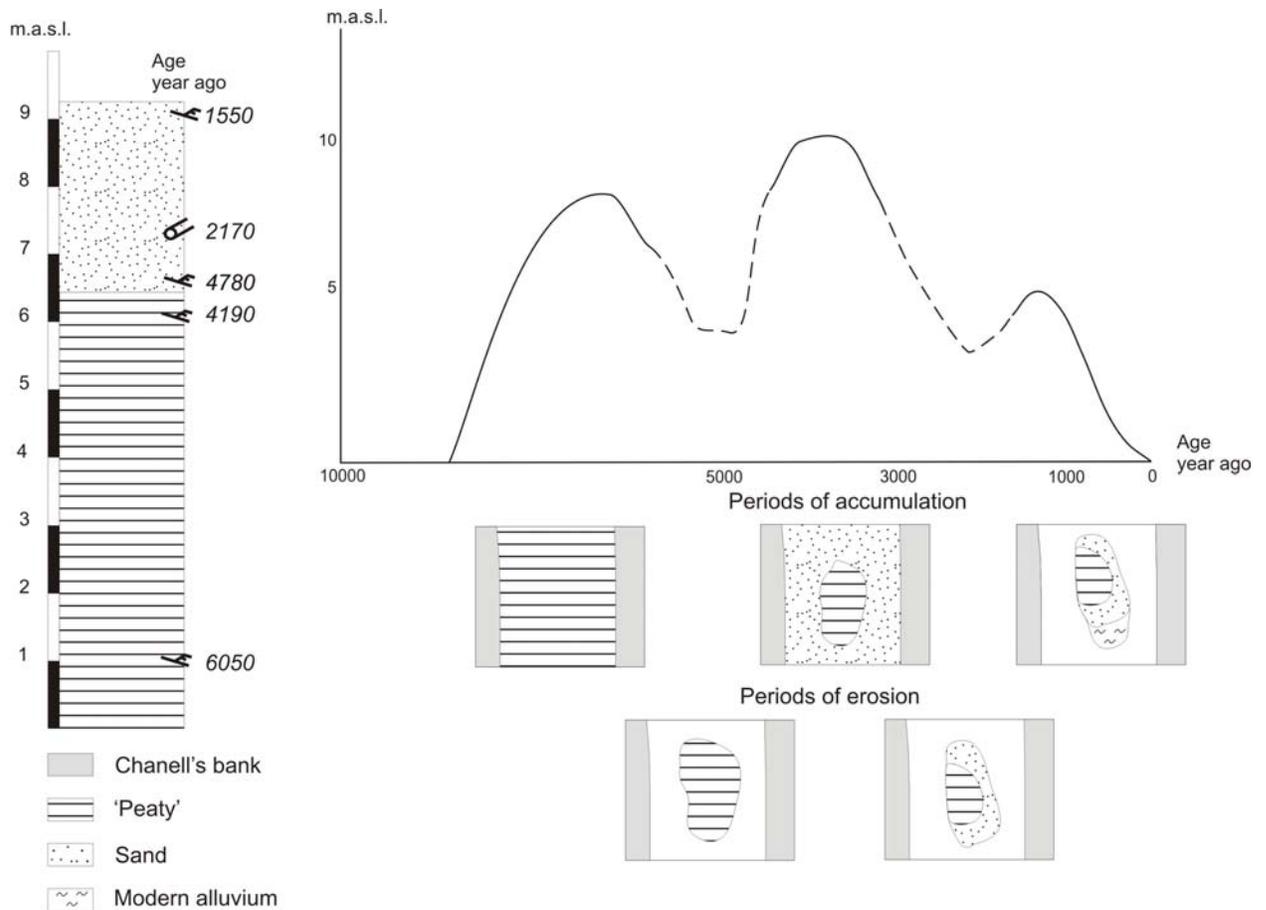


Fig.1. The scheme of sediment accumulation and formation of islands in the river Lena delta. The picture represents the island of Dzhagylakh-Sise.

Basing on dating analysis of the 1st terrace of delta and sea terrace of Lenno-Anabar coast of Laptev Sea, the researchers created the Laptev Sea level fluctuation curves during Holocene for several zones of the delta and for the region on the whole. The analysis included geomorphologic and geologic structure as well as traditional scheme of formation of islands in the delta. At the current stage of research it is only possible to make rough distinguish of delta development phases and receiving reservoir (Fig.2). The level of sea rose 200-400 years ago; 700-2000 years ago; 1-3 thousand years ago; 3.5-4 thousand years ago; 4.7-5.5 thousand years ago and about 7-8 thousand years ago. These stages are divided by shorter phases of cuttings corresponding with the drop of level of receiving reservoir.

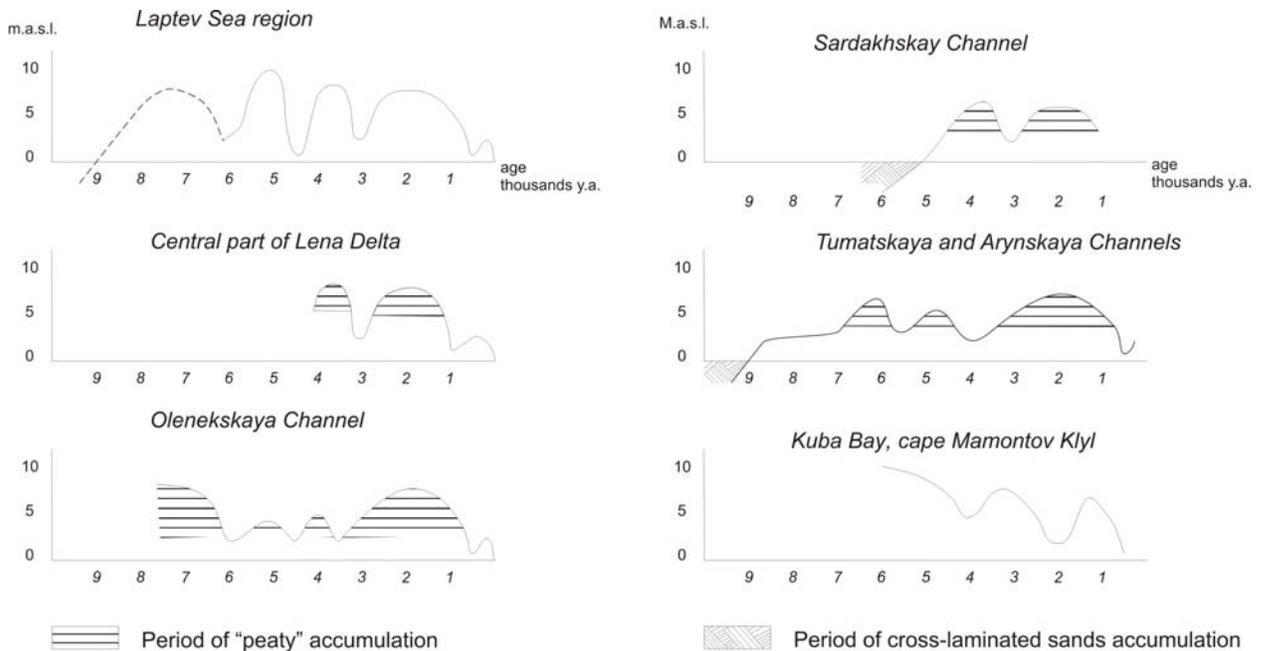


Fig.2. Fluctuation curves of sea level in different parts of the delta. General curve line of fluctuation of Laptev Sea level during Holocene.

The Holocene history of the river Lena delta is an alternation of phases of erosion, accumulation or transit of alluviums. It is notable that in different parts of delta such conditions have been formed simultaneously (Fig.3). At the beginning of Holocene, at the place of modern delta, active ice complex erosion took place. Eight thousand years ago the first plant "peaties" were formed, and this fact can evidence an increased level of the basin during that period. Six thousand years ago during sea-level decreasing the accumulated sediments were exposed to erosion, including Ice Complex relics and an island of Arga-Muora-Sise - a mass of sea sands that had been come out to the surface. Five thousand years ago the delta channels have entered estuary phase of development, when the plant "peaties" had been rapidly accumulated. Four and a half thousand years ago – the phase of erosion and accumulation of alluvial sands, was followed by the period of infilling the shallow estuaries by plant and sand sediments (three and a half years ago). 1000-500 years ago – erosion phase together with the final formation of Ice Complex remains in the delta. The modern phase of cut, forming the contemporary pattern of the delta, was foregone by a short-term raise of sea level about 400 years ago.

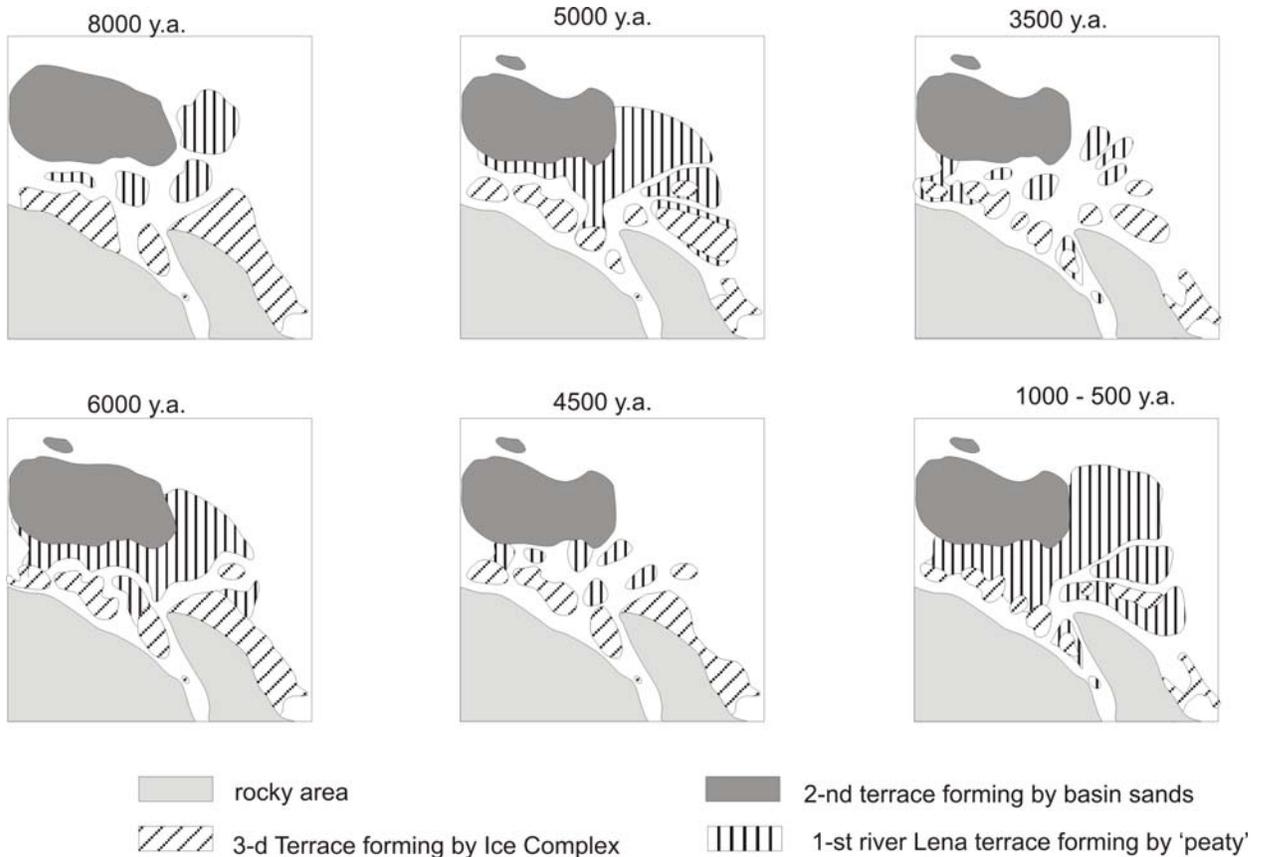


Fig.3. Paleographic reconstruction of the river Lena delta during late Neopleistocene and Holocene.

To sum up, the researchers can clearly state, that the main factor of formation of contemporary pattern of the river Lena delta are fluctuations of Laptev Sea level, having been occurred during the whole period of Holocene.

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Poster Area A

SEDIMENTATION EVENTS ON THE YERMAK PLATEAU IN THE PAST 40,000 YRS

Jens Matthiessen¹, Frank Niessen¹, Christoph Vogt², **Jochen Knies**³, Michael Pirrung⁴ and Ruediger Stein¹

¹Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

²Department of Geosciences, University of Bremen, Germany

³Norwegian Geological Survey, Trondheim, Norway

⁴Institute for Geosciences, Friedrich Schiller University, Jena, Germany

The Weichselian sequences in the Yermak Plateau area are characterized by a succession of sedimentary events that are related to the build-up and decay of ice sheets at the Eurasian continental margin and the variability in the advection of water masses of different origin. Due to an extensive expedition activity in the past 20 years a large set of sediment cores has been collected in the area that allow to describe the regional extent of these short-term events and to trace their origin. Since these events are reflected in a distinct mineralogical, organic geochemical and micropaleontological composition of discrete samples, the potential of non-destructive measurements as tools for a fast identification and regional correlation can be evaluated. The initial results of a correlation between discrete measurements and continuous downcore measurements in some sediment cores are presented to demonstrate the potential and limits of non-destructive measurements.

Poster Area A

CLIMATE CYCLES AND EVENTS IN THE PLIO-/PLEISTOCENE OF THE YERMAK PLATEAU, ARCTIC OCEAN: CAUSES AND CONSEQUENCES BASED ON X-RAY FLUORESCENCE SCANNER DATA

Christoph Vogt¹, Jens Matthiessen², Hans-J. Brumsack³ and Reinhard X. Fischer¹

¹Crystallography, Geosciences, University of Bremen, Klagenfurter Str. 2, 28359 Bremen

²Presenter, Geosciences, Alfred Wegener Institute for Polar and Marine Research, Am Handelshafen 26, 27568 Bremerhaven

³Geochemistry, Institute for Chemistry and Biology of the Marine Environment (ICBM), Carl-von-Ossietzky-University, PO Box 2503, 26111 Oldenburg

Long-term climate changes on Earth and in particular the Northern Hemisphere glaciations are related to Milankovich cycles. Up to now, these cycles were studied at a high resolution in Arctic Ocean sediments only in the last 300,000 years due to low biogenic carbonate contents and restricted age control in older sediments. Additionally, the sedimentary record yields a rather high complexity due to multiple meltwater events related sedimentation changes. The Fram Strait/Yermak Plateau gateway is a comparatively well-suited region for a study of middle to upper Pleistocene sediments because a well-constrained chronostratigraphy allows unequivocal recognition of glacial-interglacial cycles (Spielhagen et al., 2004; Knies et al., 2007). The isotope record of Hole 910A in particular shows, apart from glacial-interglacial cycles, a considerable millennial-scale variability of environmental conditions since the Brunhes/ Matuyama boundary, caused partly by frequent supply of freshwater to the Arctic Ocean (Knies et al., 2007, Matthiessen et al. in prep.). This suggests a pronounced instability of the Arctic climate system, with major consequences for the environment.

This project applies a presumably non-destructive analytical method, the X-ray fluorescence (XRF) scanner, on a high-resolution investigation of ODP sites 910 and 911 (Yermak Plateau, Arctic Ocean) to resolve Late Pliocene to Middle Pleistocene paleoenvironmental and paleoclimate variability. To fully understand and interpret the XRF Scanner data a large number of discrete samples is analysed with various mineralogical and inorganic geochemical methods to calibrate the XRF scanner measurements. These data will be related to existing and newly collected data on grain-size, carbonate and organic carbon content, and the mineralogical composition of the bulk and clay fraction. Our final goal is to better understand the sedimentary and paleoenvironmental conditions in relation to climate changes on the Northern Hemisphere at Milankovich time-scales through the last 3-4 million years.

Preliminary results are: 1) Archive and to a lesser extent work halves of the ODP910 and 911 holes are well enough preserved to perform continuous scanning. 2) Based on shipboard physical property data and supported by correlation of the new XRF scanner data a correlation of ODP holes 910A, B and D was performed for the first time. This is important as we can fill coring gaps and gaps due to previous massive sampling of ODP910A, the primary investigation hole for the initial high resolution stratigraphy (Knies et al., 2007). 3) The correlation of XRF scanning data of discrete powdered samples and the full elemental XRF analysis bears good results and the semiquantitative XRF scanner data can be validated well. 4) Most dominant lithological and sedimentological changes are well represented in the K/Ca-ratio of the sediments in particular for the times of ice-sheet built up and deglaciation times. 5) The Si/Al-ratio is strongly related increased quartz and ice-rafted debris contents as well as to grain size and to bottom current changes. 6) Diagenetic overprint is well constrained by the Mn-record of the sediments.

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Poster Area A

THE LAST DEGLACIATION OF THE BARENTS SEA

I.O. Murdmaa¹, V. Yu Lavrushin², O.V. Levchenko¹, N.P. Radionova², E.P. Shkatov³ and S.M. Sloistov⁴

¹Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia

²Institute of Geology, Russian Academy of Sciences, Moscow, Russia

³Polar Marine Expedition of Geological Survey, St. Petersburg, Russia

⁴Russian State University of Geological Survey, Moscow, Russia

More than 100 gravity cores, up to 6m long, retrieved by Russian expeditions (1997-2007) recovered glaciomarine sediments of the last deglaciation beneath Holocene marine sediments which, in turn, are underlain by the glacial till likely deposited as a non-marine basal moraine during the LGM (?). The cores are partially correlated with high-frequency seismic records to reveal seismic stratigraphy and facies. The regional unconformity well expressed in seismic records separates the lithified Mesozoic and Paleozoic bedrocks from the non-consolidated sediment cover. Most authors believe that the major unconformity is formed during the Late Weichselian glaciation as a result of glacial erosion by the grounded Barents Sea ice sheet, although some relics of older marine sediments possibly escaped the erosion. Deglaciation likely started with detachment of the outlet glaciers from the bottom and penetration of sea water into deep Bear Island, Franz Victoria and St. Anna troughs. This led to iceberg calving and deposition of iceberg-rafted or iceberg turbated marine diamicton that differs from glacial till in finer grain size, saline pore water, and very rare, but rather well preserved foraminiferal fauna. Such proximal glaciomarine facies comprising frontal marine moraine mounds, iceberg rafted and iceberg turbated varieties, as well as gravity flow deposits, directly follow the retreating ice sheet edge, and are therefore apparently diachronous. The timing of their deposition ranges from the beginning of deglaciation about 15-16 ka BP in marginal troughs to recent at the front of outlet glaciers discharging into fjords in archipelagoes. However, a time lag always exists between the glacier front retreat and the age of so-called diamicton that should be taken into account in reconstructions of the glacier front migration. A distinct boundary marked by changes in color, grain size, density, and sedimentary structures separates the marine diamicton from the overlying distal glaciomarine sediments suggesting a dramatic change in sedimentation mode. Hiatus at the top of diamicton is fixed in some cases, and the transition from proximal to distal glaciomarine sediments is marked by a reflector in seismic records. The distal glaciomarine sediments are commonly represented by laminated sequences suggesting deposition from multiple low-density gravity flows including turbidity currents. Rare occurrence of coarse debris (IRD) suggests that iceberg rafting was minor during their deposition, likely owing to retreat of glacier fronts to land. We assume that deglaciation of the Barents Sea was mainly stimulated by the northward heat transport with Atlantic water inflow to the Arctic Ocean coupled with glacioeustatic sea level rise rather than by the insolation increase or atmospheric heat transport.

Poster Area C

CENTRAL WEST SIBERIAN ARCTIC: NEWS ON THE LAST GLACIATIONS

Dmitry Nazarov

Geological Faculty, St. Petersburg University, St. Petersburg, Russia

The Quaternary cover of the rarely visited northern Gydan Peninsula has been investigated in the course of the Russian-Norwegian project PECHORA II (Palaeo Environment and Climate History of the Russian Arctic). The main questions are i) whether it was glaciated during the Late Pleistocene and ii) when exactly? The QUEEN model suggested two ice advances ca 90 and 60 kyr ago (Svendsen *et al.* 2004) whereas many Russian workers did not believe in the ice dam that presumably blocked the northbound drainage.

Two key sections have been studied in the upper reaches of river Yuribei north of the Gydan Ridge, 69°50'N/74°54'E. The base of the sequence exposed ca to 28 m a.s.l. is represented by perennially frozen diamicton with sedimentary structures typical for basal till. The massive ice body 3 m thick and 500 m long is observable within and beneath the diamicton. The ice contains debris bands, shear planes, recumbent folds and therefore is a fossil glacier. The glacial stress is indicated by shear planes dipping towards 330°. The basal units are overlain by outwash sand and varved clay.

Transition from the sand into the overlying varves is gradual. The varves are overlain by sand with current ripples and thin seams of well-rounded fine gravel. The gravelly formation contains a 6-7 m thick set of cross beds gently dipping southwards. The outwash and lacustrine formations make a transgressive/regressive series capped by a progradation delta. Such a sequence was probably formed during the active phase of the last glaciation. The OSL samples from beneath and above the varves have yielded ages 59±3, 55±3, 59±3, 69±4, 69±4 and 66±4 kyr BP suggesting a Middle Weichselian ice advance from the Kara Sea shelf.

Possible stratigraphic counterparts of this glacial complex are the icy Kara diamicton on western Yamal (Forman *et al.* 2002) and the Yenisei outwash of the last Putorana ice sheet (Astakhov and Mangerud 2007). All these formations are probably imprints of the second, Middle Weichselian advance of the Late Pleistocene Kara Ice Sheet. Then the Sopkay moraine on the Lower Ob, just above the Arctic Circle, may belong to the first, Early Weichselian ice advance of the Kara Ice Sheet. The latter possibility is supported by OSL dates 93 to 72 kyr from the base of the glaciolacustrine formation south of the Sopkay and by the mean OSL age of 68 kyr from overlying sands in southern Yamal (Astakhov 2006).

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Poster Area B

FIRST RESULTS FROM BLISS LAKE, PEARY LAND, NORTHERN GREENLAND

Jesper Olsen¹, Kurt Kjær², Svend Svend² and Alexander P. Alexander³

¹Department of Earth Sciences, University of Aarhus, Denmark

²Geological Museum, University of Copenhagen

³Department of Earth and Atmospheric Sciences, University of Alberta, Canada

As part of the LongTerm project two percussion cores (332 and 231 cm respectively) were taken in Bliss Lake, Peary Land, Northern Greenland (N83 31.227 W31 21.201) in 2006. The 332 cm core is likely to represent the entire sediment record, as coring was stopped at something really hard such as rock or permafrost. This is supported by radiocarbon dating yielding a date of 8050 – 7960 cal. yr BP (238 cm) and by taking into account that de-glaciations of the northern parts of Greenland is reported to occur in the Early Holocene. Here the first X-Ray fluorescence (XRF) results are to be presented.

The sediments display two main units; one consisting of laminated clayish silt with organic layers (occurring at top and bottom) and another of laminated organic rich deposits (black) with silt/ clay layers occurring in between. These units are clearly identified by the XRF data, in particular Fe and S counts. High S and Fe counts for the organic rich sediments are likely reflecting the deposition of iron sulphides as a consequence of increased organic productivity. The upper part of this interval is dated to approximately 8000 cal. BP. The elements of Ti, Al and K are taken to represent weathered source rock materials and display a decreasing trend towards the termination of the blackish organic unit followed by an increase to higher values. As most sediments likely are delivered to lake during spring snow melt this may be interpreted as a decreased winter snow cover and / or increased vegetation of the catchments area succeeded by increased snow cover and / or decreased vegetation cover. A similar trend is displayed by the Si to Ti ratio taken as a measure of total biogenic silica. This may indicate increasingly warmer conditions succeeded by a colder climate or alternatively isolation of the lake from Bliss Bay due to isostatic rebound succeeded by lacustrine deposition. The latter may be supported by the finding of a *Portlandia arctica* shell near the bottom of the core.

Poster Area C

LATE QUATERNARY GLACIAL AND MARINE STRATIGRAPHY ON KVADEHUKSLETTA, NORTHWEST SPITSBERGEN, INTERPRETED FROM GROUND PENETRATING RADAR (GPR) PROFILING

Heidi T. Ryen¹, Helena Alexanderson^{1,2}, Leif V. Jakobsen¹ and Jon Y. Landvik¹

¹Department of Plant and Environmental Sciences, Norwegian University of Life Sciences,
Norway

²Nordic Laboratory for Luminescence Dating, Risø National Laboratory, Aarhus University,
Denmark

Spitsbergen lies in a climatic and oceanographic complex area where size and dynamics of former ice sheets is still disputed. A complex sequence of raised beach ridges at Kvaldehuksletta, on the northwestern part of the main island, is considered to be a key site for improved understanding of the Late Quaternary glacial dynamics of the west coast of the archipelago.

The deposits are interpreted to consist of multiple generations of raised beach sequences, some predating the Late Weichselian (Forman and Miller, 1984). Lack of evidence for glacial impact has led to the conclusion that the area has not been covered by a Late Weichselian ice sheet (Forman, 1989) whilst marine data conclude that Late Weichselian ice reached the continental shelf and must have covered these low-lying areas (Landvik et al., 2005).

Extensive Ground Penetrating Radar (GPR) profiling over the raised beach sequences was performed in summer 2007, providing 2D images of the ridges' inner structure, and of the stratigraphic relationship of the beach sequences. The GPR method has provided an improved insight into the stratigraphy and geometry of these features, and increased our understanding of the depositional and glacial history of the area.

Samples for optically stimulated luminescence (OSL) dating are now being processed and will provide age control for the GPR-units.

Poster Area A

BERYLLIUM ISOTOPE VARIATIONS IN SEDIMENT CORES FROM THE ALPHA RIDGE, ARCTIC OCEAN

Emma Sellén¹, Martin Jakobsson¹, Peter W. Kubik² and Martin Frank³

¹Department of Geology and Geochemistry, Stockholm University

²Paul Scherrer Institute, Institute for Particle Physics of ETH, Zurich

³IFM-GEOMAR Leibniz Institute for Marine Sciences, University of Kiel

The Healy-Oden Trans-Arctic Expedition 2005 (HOTRAX) recovered cores along a transect across the Arctic Ocean. Here we present results from measurements of seawater-derived beryllium isotopes in cores HLY0503-09JPC and HLY0503-14JPC from the Alpha-Mendeleev Ridge. The intention of measuring beryllium (Be) isotopes is to establish a chronostratigraphy as the decrease of ¹⁰Be concentration (half-life = 1.51 Million years) with depth in the cores may provide first order sedimentation rates. The isotopes ¹⁰Be and ⁹Be were extracted simultaneously from sample aliquots by using a leaching procedure. To eliminate the dilution effect of beryllium caused by short-term changes in sedimentation rate and grain size variability, the ¹⁰Be concentration was normalized to the stable isotope ⁹Be. The results show low downcore ¹⁰Be concentrations and subsequently sedimentation rates on the order of mm/ka in both cores from the Alpha Ridge. However, we note two indications suggesting that our calculated sedimentation rates from the beryllium results may not be valid and requires further analysis: 1) the decrease of ¹⁰Be down core does not follow a well defined trend; 2) a comparison with preliminary results from nannofossil studies of cores HLY0503-14JPC and HLY0503-08JPC located nearby HLY0503-09JPC indicates much higher sedimentation rates than we obtained from the ¹⁰Be data (Backman and Fornaciari pers. comm.). The pronounced decrease of ¹⁰Be with core depth may imply a stronger effect of sea ice shielding of atmospheric inputs, whereas the ⁹Be increase with depth may point to a stronger continental input of ⁹Be.

Poster Area B

CONSTRAINING A GLACIOLOGICAL MODEL OF THE GREENLAND ICE SHEET USING RELATIVE SEA LEVEL DATA

Matthew Simpson¹, Glenn Milne¹, **Antony Long**² and Philippe Huybrechts³.

¹Department of Earth Sciences, Durham University, Durham, DH1 3LE, UK

²Department of Geography, Durham University, Durham, DH1 3LE, UK

³Vrije Universiteit, Department of Geography, Pleinlaan 2, B-1050, Brussels, Belgium.

Three approaches can be employed to reconstruct the deglaciation history of ice sheets: (1) Glaciological modelling that simulates past ice sheet evolution forced by prescribed climatic conditions; (2) modelling observations related to glacial isostatic adjustment to constrain the space-time ice mass distribution; (3) directly constraining the lateral and height extent of ice from field observations. Most previous studies have combined only two of these approaches (generally (1) and (3) or (2) and (3)). Here we employ all three approaches to place the maximum number of constraints possible on the resulting model reconstruction (e.g. Tarasov and Peltier, 2002). We focus on new and existing high quality observations of relative sea level (RSL) obtained from isolation basins to constrain a 3-D thermomechanical Greenland ice model from the last glacial maximum to present day. Sensitivity experiments using the Greenland model of Huybrechts (2002) and the global ICE-5G model (Peltier, 2004) show that the data-model misfits are dominated by the Greenland component ice model (rather than Earth model viscosity structure or the non-Greenland component of the ice model). We go on to improve the Huybrechts (2002) ice model by revising the climatic and sea-level forcing to arrive at a much improved fit to the RSL data. Of particular interest is the response of the ice sheet to the peak warming period known as the Holocene thermal maximum (HTM). The ice sheet is thought to have retreated to a minimum volume and extent during the mid-Holocene. Our new model reaches a minimum extent/volume, equivalent to a eustatic sea-level change of c. 0.3 m, at 4 ka BP. This is in agreement with current field constraints.

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Poster Area A

HIGH-RESOLUTION HOLOCENE RECORDS OF SURFACE AND DEEP WATER MASSES ON THE YERMAK PLATEAU

Robert F. Spielhagen^{1,2}, H. Christian Hass³, Niels Nørgaard-Pedersen⁴

¹ Mainz Academy of Sciences, Humanities and Literature

² Leibniz-Institute of Marine Sciences, IFM-GEOMAR, Kiel

³ Alfred-Wegener-Institute, List/Sylt

⁴ GEUS, Copenhagen;

Holocene changes of surface and bottom water masses are reconstructed on decadal-scale resolution from a multi-proxy study of Holocene sediments obtained from the northwestern Yermak Plateau (Arctic Ocean, ca. 1000 m water depth). Stratigraphy is based on a series of ¹⁴C-AMS datings. Proxies include oxygen and carbon isotope values of planktic and benthic foraminifers, planktic foraminifer abundances, and grain size distributions. From these data sets we are able to reconstruct the variability of Atlantic Water inflow to the Arctic Ocean at its upper and lower level.

Our results indicate a strong Atlantic Water inflow in the early Holocene (10-8 cal-ka) with equally strong bottom current activity and a sea ice margin situated on the Yermak Plateau. This interval was interrupted by a short-term interval corresponding to the 8.2 ka cold climatic event. By 7.5 ka, bottom currents had seized, but a strong surface water inflow of high salinity is indicated by high carbon and oxygen isotope values of planktic foraminifers, which reached maximum values at 5.8-3.5 ka. The Late Holocene environment was characterized by stronger bottom currents around 2 ka, less inflow during the "Little Ice Age" and a strong warming in the "Industrial Period".

Poster Area C

A NEW RECONSTRUCTING AND DATABASE OF BUILD-UP AND DEGLACIATION OF THE EURASIAN ICE SHEET

Richard Gyllencreutz¹, Jan Mangerud¹, John Inge Svendsen¹ and Øystein S. Lohne¹

¹ Department of Earth Science & Bjerknes Centre for Climate Research, University of Bergen, Norway

The chronology and pattern of the Eurasian ice sheet's advance and decay is of key importance for Late Quaternary environments. The increasing resolution of ice sheet- and climate models demands detailed information in digital format about the ice sheet configuration on a calendar year time scale. We address this by building a database with all available dates, and a GIS with all geomorphologic features, that are relevant for the ice configuration through the Last Glacial Maximum and the following deglaciation, based on results from the literature. The database-GIS solution (called DATED) offers several new, important features:

- 1) Data is stored in a digital format, which can be easily incorporated into models, from the start, but also facilitates recalibration of dates.
- 2) All data has references to the original source, which greatly facilitates validation, reinterpretation and development of the reconstructions.
- 3) The data will be available on the internet to the scientific community (end of 2008).
- 4) The database and GIS can be searched using spatial queries, and the ice sheet reconstructions can be used for calculations.

Reconstructions of the ice sheet configuration is presented as thousand-year time slices of the advance and decay of the Eurasian ice sheet between 25 and 10 thousand (calendar) years ago, based on chronologic, geomorphologic and stratigraphic data from the literature. In order to enable handling of error estimates in ice sheet modeling using our reconstructions, we have made three reconstructions for every time slice: a maximum, a minimum and a "probable" ice sheet configuration, based on the limitations of the data at hand. These limitations include uncertainty in dates, geographic and stratigraphic correlations, and lack of data, which all had to be translated into a pure location uncertainty of the ice margin at the fixed time of each time slice. Therefore, the max- and min reconstructions do not represent quantitative error margins (such as standard deviations), but give a reasonable indication of the magnitude of uncertainty for each reconstruction.

The total ice sheet area was calculated for the Eurasian ice sheets in each time slice, done separately for the max, probable and min reconstructions. The results indicate that the maximum glaciated area was about 5 million km², between 22 and 19 thousand years ago. The uncertainty for the reconstructions amounts to about 1 million km² (about 1/5 of the maximum area) for most of the record before the Younger Dryas, indicating significant gaps in the knowledge of the Eurasian ice sheet configuration. Our database and GIS will significantly facilitate the identification of the areas and time periods where data is lacking, which can guide future studies and refine the reconstructions.

This is the first, preliminary output of the DATED database project, and is specifically aimed to constrain the ice sheet modeling efforts within the ORMEN project. The building of the database and the GIS is still ongoing, and the first version will be available to the scientific community by the end of 2008.

Poster Area C

MICROFOSSIL EVIDENCE FOR PAST ENVIRONMENTAL CHANGES OF THE LAPTEV SEA SHELF DURING THE POSTGLACIAL SEA-LEVEL RISE

Ekaterina Taldenkova¹, Henning A. Bauch², Anna Stepanova³, Irina Pogodina⁴ and Yaroslav Ovsepyan⁵

¹Geographical Faculty, Moscow State University, Moscow, Russia

²Mainz Academy of Science, Humanities and Literature, c/o IFM-GEOMAR, Kiel, Germany;

³Paleontological Institute RAS, Moscow, Russia

⁴Murmansk Marine Biological Institute, Murmansk, Russia

⁵Geological Faculty, Moscow State University, Moscow, Russia

Fossil ostracods and foraminifers were investigated in postglacial sediment sequences from river paleovalleys of the Laptev Sea shelf. The four AMS¹⁴C-dated cores recovered from water depths between 20 and 60 meters cover an age range back to 12.2 cal.ka.

In the cores from the outer-middle shelf (45-60 m water depth), an upcore change of fossil assemblages from brackishwater estuarine to modern marine ones evidences environmental changes related to sea-level rise and shelf flooding. Although the overall succession of fossil assemblages is similar in all studied cores, their timing is different in accordance with specific water depths of the sites, distance from the coast, river runoff influence and bottom hydrodynamics (Taldenkova et al., 2005). Sediment sequence from the modern inner shelf region (20 m water depth) was accumulated during the last 6 cal.yrs, i.e. after the sea-level stabilization close to its modern position (Bauch et al., 2001), and contains a modern-like inner-shelf assemblage dominated by shallow-water marine and river-proximal species.

On the middle-outer shelf, the presence of relatively deep-living benthic species and planktic foraminifers (including subpolar species) in fossil assemblages of both the early and late stages of shelf inundation evidences the influence of bottom reversed currents transferring saline water from the open-water areas onto the shelf along the river paleovalleys (Dmitrenko et al., 2001; Wegner et al., 2005). After about 7 cal.ka, a simultaneous increase in relative abundance of both the deep-living and river-proximal species is recorded in the outer-shelf cores. Species of the latter group are most likely ice-rafted to this offshore area. The enhancement of bottom reversed current activity and ice-rafting might be due to combined influence of climate cooling and intensification of wind-induced estuarine circulation. In the inner shelf region, periodic strengthening of marine influence in the bottom-water layer is reflected by an increase in the total abundance and diversity of microfossils, as well as proportional representation of relatively deep-living species including planktic foraminifers. Stronger marine influence in the bottom-water layer is often coincident with increasing surface-water freshening as reflected by composition of diatoms and dinoflagellates in the same core (Polyakova et al., 2006). Thus, these facts also point to an intensification of estuarine circulation on the shelf especially during the time interval 2-4 cal.ka.

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Poster Area C

PLEISTOCENE GLACIATION OF THE NEW SIBERIAN ISLANDS: THEME OF A DESIRABLE JOINT APEX PROJECT?

V.E.Tumskoy and L. Schirrmeister

119991, Leninskie Gory, Moscow State University, Faculty of Geology

New Siberian Islands are one of the most difficult for access and unexplored area of the Russia. Quaternary deposits of the islands contains huge masses of ground ices of different origin and represent a sort of "Cryolithological Natural Reserve".

Climate of the Eastern Arctic (including the New Siberian Islands) was significantly more continental and dry comparing with west- or eastward regions during the Pleistocene and Holocene. That is why a most of researchers consider a lack of glaciations here that was typical for other areas during the Pleistocene cool periods. A most of ground ice are ice wedges and segregation ice which was forming in the course of sedimentation. Though massive ground ices which occur at the north of the New Siberian Islands differ from above mentioned ice types. Previously all huge masses of ground ices on the New Siberian Islands were believed as remnants of buried passive glacier (Toll, 1897) or as snow ice (Ivanov, Yashin, 1959) or injection ice (Gasarov, 1981). Most of scientists believe they as syngenetic ice wedges after the middle of XX century. Beginning from that time massive ground ice on New Siberian Islands did not investigated. V.E.Tumskoy, M.A.Anisimov and A.E.Basilyan firstly investigated massive ground ices and including deposits on the Novaya Sibir and Faddeyevsky islands at 2000-2003 in the frames of multidisciplinary project "High latitude Arctic: Nature and Human" (PI - V.V.Pitulko). The outcrops located on the northern coasts of islands show the unique sections of massive ice and deposits with thickness more 30 m. Massive ices and enclosing deposits are intensive folded and dislocated. Blocks of frozen Pliocene-Quaternary deposits – xenoliths, which were moved up to hundreds meters, were described in sections. Glacial-scoured stones were founded on the tundra surface. Massive ice overlain with discordant contact by shallow water marine deposits with mollusks. These deposits were frozen both from massive ice boundary and from top. Marine deposits overlain by continental very ice-rich deposits with ice wedges, named Ice-Complex. According to structure of sections, results of petrographic, gidrochemistic and isotopic analysis we believe that massive ground ice of the New Siberian Islands are remnants of the bottom parts of dynamic glacier cover. It moved from the north-east and do not reached Lyakhovsky Islands. According to stratigraphic position we estimated an age of glaciations as end of the Middle Pleistocene. Glacioisostatic movements together local marine transgressions and regressions were results of the glaciations dynamic. Glaciations had a significant influence on adjacent areas where accumulated continental (i.e. glacifluvial) deposits.

Many questions about massive ground ices are unsolved up to now: age, conditions of it formation, evolution and degradation, glacioisostatic movements, processes of it burying under marine deposits, etc.

In order to approach to these problems we propose joint studies by geocryologists, glaciologists, marine geologists, paleontologists, geochronologists, paleoecologists, sedimentologist, and geochemists within the frame of the APEX community on the Novaya Sibir and Faddeyevsky Islands earliest in summer 2010. Envisaged field work should comprise of detailed exposure studies devoted to understand ice structure and construction in a multidisciplinary way. Participation of are particularly welcome. Subsequent geophysical surveys and permafrost drilling could allow covering the discrete ice bodies each of them measuring several kilometres in length and width.

The presented poster shows the most impressive pictures of exposures with buried ice and summarizes previous study results. It will suggest concept ideas on how to study the glaciation periods as covered by the New Siberian Islands formations.

Poster Area B

RAPID CHANGES OF GREENLAND TIDEWATER OUTLET GLACIERS: INSIGHTS FROM NUMERICAL MODELLING

Andreas Vieli and Faezeh M. Nick

Department of Geography, Durham University, South Road, Durham DH1 3LE

Rapid dynamic changes such as surface thinning, flow acceleration and retreat have been observed for several outlet glaciers in Greenland in recent years and led to a significant increase in mass loss from this ice sheet. It has been suggested that the onset of these rapid changes is linked to the recent high summer air and ocean temperatures, the triggering mechanism and controlling feedback mechanisms are however not well understood. In this study we use a flowline model that considers longitudinal stress coupling and a moving grounding line to investigate the dynamical response of such outlet glaciers to near frontal perturbations such as enhanced sliding, weakening of margins, enhanced surface melt and reduced buttressing. Applications to Helheim Glacier (East Greenland) show that perturbations near the front propagate very rapidly upstream and that basal over deepening play a crucial role for amplifying such perturbations. The presented modelling work gives us important new insights for better understanding the dynamic of such tidewater outlet glaciers and has implications on the interpretation of palaeo ice-sheet reconstructions in the Arctic.

Poster Area A

CORRELATION OF HIGH-RESOLUTION RECORDS IN SEDIMENT CORES FROM THE WESTSPITSBERGEN CONTINENTAL MARGIN AND THE YERMAK PLATEAU

Kirstin Werner¹, Robert F. Spielhagen¹, H. Christian Hass² and Frank Niessen³

¹IFM-GEOMAR, Kiel, Germany

²AWI, Wattenmeerstation Sylt, Germany

³AWI, Bremerhaven, Germany

Within the HOVAG project (“Holocene Variability in the Arctic Gateway”) long sediment cores obtained from selected locations on the western Svalbard margin and the Yermak Plateau (Arctic Ocean) during cruise leg MSM05/5b of RV “Maria S. Merian” in summer 2007 are analyzed to reconstruct the Holocene variability of Atlantic Water advection to the Arctic Ocean and the position of the sea ice margin. First results including MSCL logging and color scanning can be correlated to other cores from this region. Accumulation of relatively thick Holocene sedimentary sequences is attributed to sediment transport at certain water depths along the margin and deposition of fine-grained sediments at sites of “lee positions” with diminished flow velocities. With these deposits high-resolution paleoceanographic reconstructions of environmental changes can be achieved for an area where significant changes in the last few centuries and probably also in the rest of the Holocene occurred.