Expeditions in Siberia in 2005

Edited by Lutz Schirrmeister

Russian-German Cooperation SYSTEM LAPTEV SEA:

The Expedition COAST I

Edited by

Paul Overduin

The Expedition Lena 2005

Edited by

Lutz Schirrmeister, Dirk Wagner, Mikhail N. Grigoriev, Dimitry Yu. Bolshiyanov v

Russian-German Cooperation Yakutsk – Potsdam:

The Expedition CENTRAL YAKUTIA 2005

Edited by

Bernhard Diekmann, Sebastian Wetterich, Frank Kienast

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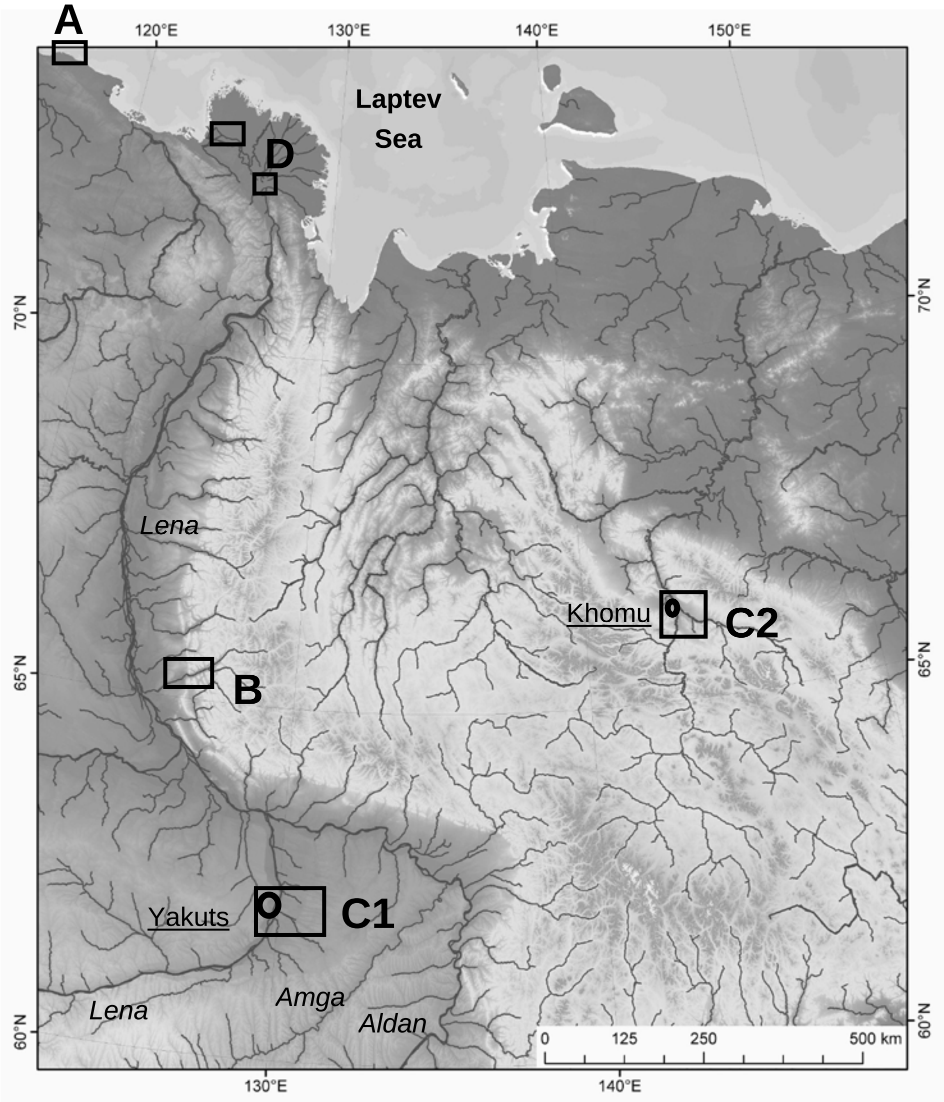
Editorial

Siberia, more specifically Yakutia, was the region of focus for the field expeditions undertaken by the periglacial research section of AWI in 2005. The spectrum of field work comprises drilling from sea ice into submarine permafrost of the Laptev Sea (COAST-I, April 2005), drilling from lake ice into lake deposits in Central Yakutia (YAKUTIA 2005, spring) and the collection of modern ecological data sets from various waters for pollen, diatoms and ostracod analysis as well as studies of modern plant associations in Central and east Yakutia (YAKUTIA 2005, summer). In addition, long-term observations and measurements of trace gas emission, pedogenic and microbial characteristics of tundra soils in the Lena River Delta were continued. Concurrently, studies of Quaternary palaeoenvironment and landscape dynamics and of the characteristic of periglacial land surfaces were conducted (LENA 2005). All expeditions were carried out in close cooperation with Russian institutes and public institutions. This volume summarizes the field results of these expeditions. In addition, it provides a documentation of field data, which will form the basis of subsequent research and Russian-German science cooperation in Siberia.

Expedition	Region	Time frame	Leaders	Pages
COAST-I	Western Laptev Sea	23.03. - 09.05.2005	Volker Rachold Mikhael Grigoriev	
YAKUTIA 2005, spring	Beliakh Lake Verkhoyan Mountain	05.04. – 06.05.2005	Bernhard Diekmann	
YAKUTIA 2005, summer	Yakutsk region Momski region	05.07 – 28.08.2005	Ulrike Herzschuh	
LENA 2005	Lena River Delta	07.08 – 08.09.2005	Dirk Wagner Eva-Maria Pfeiffer Mikhael Grigoriev Lutz Schirrmeister	

This report is organized according to the single expeditions. The authors of the individual chapters are responsible himself for the correctness of the contents.



Study locations of the Expeditions in Siberia 2005 Map compiled by G. Grosse using data from GLOBE task team, 1999

A – Coast of Cape Mamontov Klyk, B – Beliakh Lake. C1 – Yakutsk region and Lena-Amga-Interfluve, C 2 – Momski region, D – Study areas in the Lena Delta

Russian-German Cooperation SYSTEM LAPTEV SEA:

The Expedition COAST I:
COAST Drilling Campaign 2005:
Subsea permafrost studies in the near-shore zone of the Laptev Sea

P. P. Overduin, M. N. Grigoriev, R. Junker, V. Rachold,
V. V. Kunitsky, D. Yu. Bolshiyanov, L. Schirrmeister

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The Expedition COAST I

1. Background and Objectives

One of the main foci of the new Laptev Sea System Project “Dynamics of Permafrost” is the evolution of the sub-sea permafrost within the near-shore zone of the shallow shelf. Studies of permafrost evolution in the coastal zone allow us to understand the on-shore/off-shore permafrost system evolution more precisely. Within the framework of Russian-German cooperation, relatively deep drilling by a commercial drilling team was conducted in the spring of 2005. There are only a few drilling transects within the shore face profile of the Asian Arctic Seas. Previous transects were drilled from the sea ice in spring or from small drilling platforms. As usual for the shallow Laptev Sea shelf with its thermal abrasion coastline, the sub-sea permafrost table is found by drilling to depths of 5-60 metres. The formation of new sub-sea permafrost has occasionally been observed in the shallows, in association with bottom accumulative deposits (Grigoriev N. F., 1966).

The COAST expedition sought to recover permafrost material in a transect spanning the onshore and offshore domains horizontally, and reaching from surface material to as great a depth as possible, in a region of the Laptev Sea coast minimally affected by fluvial and deltaic deposition. The recovered material thus provides for a temporal sequence of changes in permafrost since at least the last transgression. The Laptev Sea coast is heavily affected by erosion and can be regarded as a natural laboratory for coastal evolution. The region between the Olenyek and Anabar River deltas (Cape Mamontov Klyk) was selected, since the influence of fluvial waters and deltaic deposition generally decreases with distance from the river deltas. Cores were drilled along a 12 km transect from terrestrial permafrost to offshore, marine-affected permafrost. The transformation from terrestrial to submarine permafrost in the western and central Laptev Sea region can be studied using this material.

The coastal drilling transect campaign was originally planned for the spring of 2004, but was delayed until the spring of 2005 due to problems obtaining research permits. Investigations completed during the first two years concentrated therefore on the evaluation of available sample material, which had been obtained during preliminary investigations. Permafrost drilling took place at Cape Mamontov Klyk in the spring of 2003. In the summer of 2003 the expedition “Lena-Anabar 2003” led to extensive field work, including the morphology and bathymetry of the coring locations and extensive sampling (Schirrmeister et al., 2004).

The temporal and spatial variability of permafrost thickness and distribution in the Laptev Sea is closely coupled to global Quaternary climatic cycles. Since the region was hardly glaciated, cold, deep terrestrial permafrost developed on the shelf during cold-period marine regressions. During interglacial periods, marine transgressions flooded the continental shelf. The offshore, terrestrial, permafrost sediments were inundated and fell under marine influence. The effects of flooding on permafrost are still poorly understood. It is accepted that changes in the thermal regime at the sediment surface, the geocryological structure of the sediments, and, in particular, pore water salinity play a crucial role. In the nineteen-seventies, several American and Russian authors reported on and investigated submarine permafrost and salinity profiles (Ponomarev 1950, Antipina et al. 1981, Soloviev 1981, Telepnev 1981, Zhigaev 1981, Romanov & Kunitsky 1985, Fartyshev 1993*)* This work aims at expanding on these studies in a co-operative effort between European and Russian scientists.

Acknowledgements

The success of the COAST Drilling Campaign 2005 would not have been possible without the help of the Tiksi Hydrographical Base team, which organized field transportation: Dmitry Melnichenko (chief), Victor Dobrobaba, Vladimir Yakshin, Timophey Sidorov, Alexander Saphin, Yuri Tyazhelukhin, Yuriy Vlasov and Sergey Kamanin, and the Yakutsk Geological Prospect-Survey Expedition, Drilling Department team: Vitaly Makagonov (chief), Sergey Gladchenko, Valerie Ternovoy, Vladimir Kobzev, Valerie Dodonov and Mikhail Skuratov (drilling crew).

The COAST I expedition was a contribution to the joint research project "Process studies of permafrost dynamics in the Laptev Sea" (project number 03G0589) funded by the German federal ministry of Education and Research (BMBF) as well as to the Russian German Science Cooperation "SYSTEM LAPTEV SEA":

Figure 1: Drilling camp on the sea ice just offshore of the Cape Mamontov Klyk coastline. The expedition took place in April 2005

2. Logistics and itinerary

Due to problems obtaining research permits, the drilling activities for COAST had to be shifted from the spring of 2004 to the spring of 2005. Since the drilling campaign took place one year later than originally planned, analyses of the recovered sediment material are still under way. A variety of data is available however, including descriptions of the extent of material recovered and its thermal, cryogenic, geochemical and lithological characteristics.

Details of the itinerary, participating institutions and expedition participants are listed in Tables 1 to 3. Field work was accomplished through the use of an equipment caravan traveling over the sea ice to the drilling location. The drilling rig, well tubes, bore casing and additional equipment were delivered from Yakutsk to Tiksi by two cargo air-freighters (AN-12). The expeditionary transport caravan consisted of a sledge-tractor train, including two caterpillar tractors (S-160), a cross-country vehicle (GAZ-71), the drill rig (URB-2A-2) on skids, two two-storied mobile-homes (baloks) and three cargo snow-sledges with various equipment, diesel oil, and bore casings, etc. The caravan started from Tiksi on March 28, 2005. The journey lasted two weeks, and mainly followed river and sea ice through the Lena Delta and then across Olenyek Bay. The thickness of sea ice ranged between 1.7 and 2.1 m. The scientific team, excluding M. Grigoriev, flew by MI-8 helicopter on April 11 to join the caravan.

The scientific team of the expedition consisted of 6 members: Volker Rachold, Waldemar Schneider (AWI-Potsdam, Germany), Ralf Junker (University Bremen, Germany), Mikhail Grigoriev, Viktor Kunitsky (Permafrost Institute, Yakutsk, Russia) and Dmitriy Bolshiyanov (AARI, St-Petersburg, Russia).

During the journey to Cape Mamontov Klyk and back, the transport team encountered serious obstacles in the form of sea ice cracks, hummocks, snowdrifts and sand storms on the ice. Not far from the Olenyek Delta, the engine of one of the caterpillar tractors broke and the transport team had to wait a few days for a new tractor (S-130) from Tiksi. Early in the morning of April 11 the sledge-tractor train reached its destination point – Cape Mamontov Klyk. The length of the route (Tiksi - Cape Mamontov Klyk) was more than 500 km. The total weight of the sledge-tractor train was more than 130 tons.

Table 1: List of participants

Name	e-mail	Institution
Dmitriy Bolshiyanov	bolshiyanov@aari.nw.ru	AARI
Victor Dobrobaba	baza@tiksi.sakha.ru	THB
Valerie Dodonov	lengeo@mail.sakha.ru	YGPSE
Sergey Gladchenko	lengeo@mail.sakha.ru	YGPSE
Mikhail Grigoriev	grigoriev@mpi.ysn.ru	PIY
Ralf Junker	ralf.junker@uni-bremen.de	UB
Sergey Kamanin	baza@tiksi.sakha.ru	THB
Vladimir Kobzev	lengeo@mail.sakha.ru	YGPSE
Viktor Kunitsky	kunitsky@mpi.ysn.ru	PIY
Volker Rachold	volker.rachold@iasc.se	AWI
Alexander Saphin	baza@tiksi.sakha.ru	THB
Timophey Sidorov	baza@tiksi.sakha.ru	THB
Mikhail Skuratov	lengeo@mail.sakha.ru	YGPSE
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Valerie Ternovoy	lengeo@mail.sakha.ru	YGPSE
Yuri Tyazhelukhin	baza@tiksi.sakha.ru	THB
Yuriy Vlasov	baza@tiksi.sakha.ru	THB
Vladimir Yakshin	baza@tiksi.sakha.ru	THB

Table 2: List of participating institutions

AARI	Arctic and Antarctic Research Institute, Bering St. 38, 199397 St. Petersburg, Russia
AWI	Alfred Wegener Institute, Research Unit Potsdam, PO Box 60 0149, D-14401 Potsdam, Germany
PIY	Permafrost Institute, Russian Academy of Science, 677018 Yakutsk, Yakutia, Russia ul. Merzlotnaya 36
THB	Tiksi Hydrographical Base, Tiksi, Yakutia, Leninskaya St., 15
UB	Department of Geosciences, University of Bremen, Postfach 330440, 28334 Bremen, Germany
YGPSE	Yakutian Geological Exploring-Survey Expedition: 677014, Russia, Yakutsk, Kalvits Str, 34, Yakutian Geological Exploring-Survey Expedition

Figure 2: Expedition team, including the drilling crew, tractor drivers and the cook. Expedition participants were: Dmitriy Yuryevich Bolshiyanov, Mikhail Nikolayevich Grigoryev, Victor Vladimirovich Kunicki, Valerie Anatoljevich Ternovoy, Vladimir Nikolayevich Kobzev, Sergey Ivanovich Gladchenko, Valerie Ivanovich Dodonov, Mikhail Garikovich Skuratov, Victor Vasiljevich Dobrobaba, Vladimir Nikolayevich Yakshin, Timofey Nikolayevich Timofeev, Aleksandr Nikolayevich Safin, Yuri Vladimirovich Tyazhelukhin, Volker Rachold, Waldemar Schneider, and Ralph Junker (plus one unnamed participant).

Figure 3: Drilling platform and support vehicles on the ice

Table 3: COAST Expedition Itinerary

Date	Activity
23.03.2005	Cargo flight (AN-12) from Yakutsk to Tiksi (well tubes, boring casing and various equipment).
26.03.2005	Cargo flight (AN-12) from Yakutsk to Tiksi (drilling rig): M. Grigoriev, S. Gladchenko, V. Ternovoy, V. Kobzev, V. Dodonov, M. Skuratov.
28.03.2005	Departure from Tiksi (sledge-tractor train): M. Grigoriev, S. Gladchenko, V. Ternovoy, V. Kobzev, V. Dodonov, M. Skuratov, V. Dobrobaba, V. Yakshin, T. Sidorov, A. Saphin, Yu. Tyazhelukhin, S. Kamanin.
5.04.2005	Departure from Tiksi (additional caterpillar tractor instead of destroyed near Olenyek Delta): Yu. Vlasov.
5.04.2005	Flight from Berlin (Schoenefeld) to Moscow (Domodedovo): V. Rachold, W. Schneider, R. Junker.
6.04.2005	Flight from Moscow (Domodedovo) to Yakutsk: V. Rachold, W. Schneider, R. Junker, D. Bolshiyanov.
7.04.2005	Flight from Yakutsk to Tiksi: V. Rachold, W. Schneider, R. Junker, D. Bolshiyanov, V. Kunitsky.
11.04.2005	Arrival of Sledge-tractor train at Mamontov Klyk Cape.
11.04.2005	Flight by helicopter MI-8 from Tiksi to Mamontov Klyk Cape: V. Rachold, W. Schneider, R. Junker, D. Bolshiyanov, V. Kunitsky.
26.04.2005	Return flight by helicopter MI-8 from Mamontov Klyk Cape to Tiksi: M. Grigoriev, V. Rachold, W. Schneider, R. Junker, D. Bolshiyanov, V. Kunitsky, Yu. Tyazhelukhin.
27.04.2005	Departure from Mamontov Klyk Cape (sledge-tractor train): S. Gladchenko, V. Ternovoy, V. Kobzev, V. Dodonov, M. Skuratov, V. Dobrobaba, V. Yakshin, T. Sidorov, A. Saphin, Yu. Tyazhelukhin, S. Kamanin, Yu. Vlasov.
28.04.2005	Flight from Tiksi to Yakutsk: M. Grigoriev, V. Rachold, W. Schneider, R. Junker, D. Bolshiyanov, V. Kunitsky.
29.04.2005	Flight from Yakutsk to Moscow (Domodedovo): V. Rachold, W. Schneider, R. Junker, D. Bolshiyanov.
30.04.2005	Flight from Moscow (Domodedovo) to Berlin (Schönefeld): V. Rachold, W. Schneider, R. Junker.
9.05.2005	Arrival of aledge-tractor train in Tiksi.
11.05.2005	Flight from Tiksi to Yakutsk: S. Gladchenko, V. Ternovoy, V. Kobzev, V. Dodonov.
15.05.2005	Cargo flight (AN-12) from Yakutsk to Tiksi (drilling rig): M. Skuratov.

3. Field Methods and Sample Recovery

3.1 Coring

The COAST expedition used a drilling rig (URB-2A-2) with a hydraulic rotary-pressure mechanism. Depending on sediment characteristics, it is capable of drilling bore holes up to 250-300 m deep. Well tubes and bore casings (liners) from 1.5 to 4 m length and from 70 to 160 mm (89, 108, 127 and 146) diameter were used during drilling. Casing size decreased with penetration depth and lined the complete borehole. Nevertheless there were some problems with water infiltration in the bore holes, sometimes even within the frozen stratum of sub-sea sediment. Altogether about 240 m of core was recovered from 5 boreholes. After the extraction of the core, it was laid on special tables, cleaned, described and sampled. The core material was divided into four categories: for geosciences (AWI-Potsdam), biosciences (AWI-Potsdam), geochemistry (immediate processing) and geochronology (AARI-St.-Petersburg). The samples were labeled and packed in thermo-insulating boxes. These boxes were covered with snow (to maintain relatively stable temperature conditions). All samples were transported frozen to Tiksi by helicopter and then to Moscow, St. Petersburg and Germany.

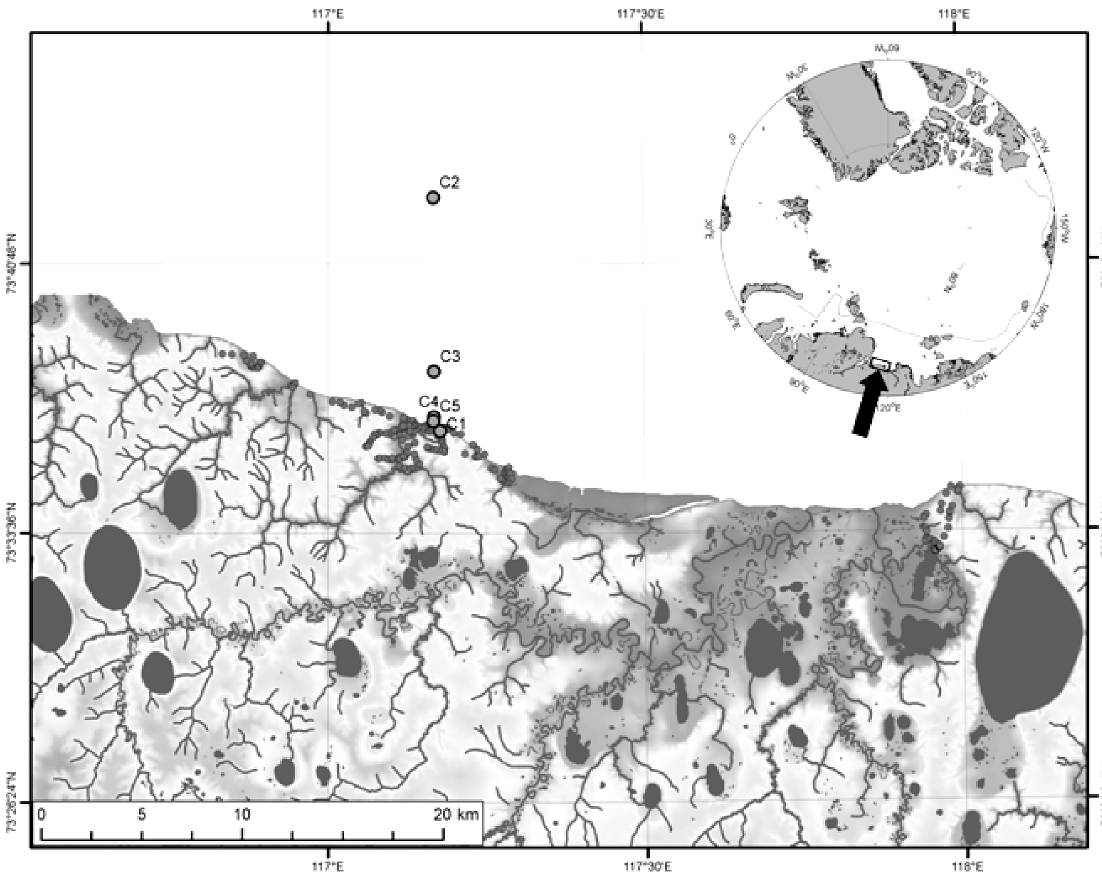

Figure 4: Cape Mamontov Klyk and borehole locations (map G. Grosse)

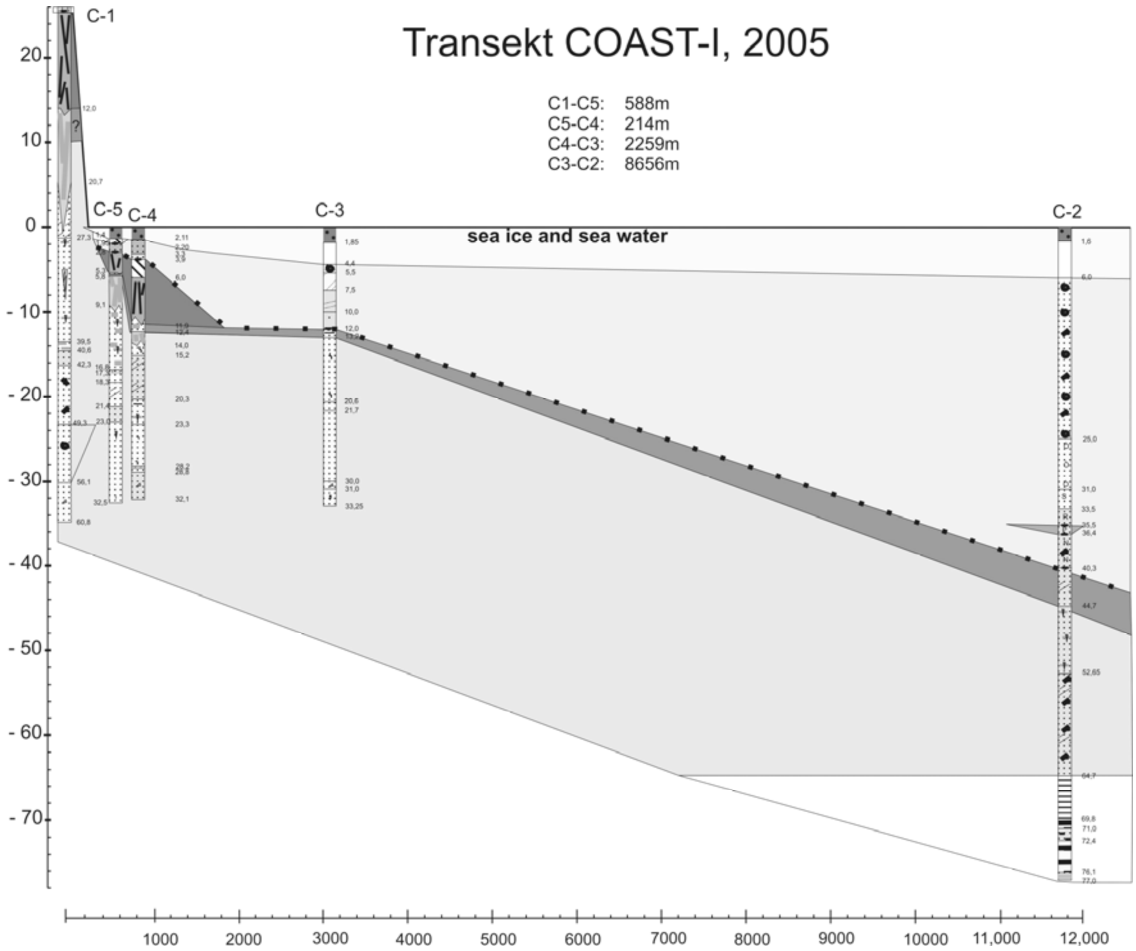

Figure 5: Schematic of drilling transect (not to horizontal scale), with coarse lithological classification. Details on the lithology are given in Figures 6 to 10.

The expedition resulted in 5 cores (Figure 5 and Tables 4 to 7). The borehole profile was located along a line of longitude (approximately 117 ° 10' E) in the Cape Mamontov Klyk area, from the coastal zone to the north. Core 1 (C-1) was drilled on the mainland at a distance of approximately 100 m from the coastline and reached a depth of approximately 60 m. Core 1 contained exclusively frozen, terrestrial, permafrost-affected material. It serves as reference material for terrestrial permafrost unaffected by transgression or direct erosion. A temperature string was installed in the borehole after drilling and permafrost temperatures have been recorded since the time of drilling [editor's note: a complete year of temperature data was recovered in the summer of 2006, and measurements continue]. The results will contribute to the international measuring network for the collection of permafrost temperatures (the Global Terrestrial Network for Permafrost, GTN-P).

Table 4: Borehole coordinates.

Borehole	Latitude	Longitude
Borehole C-1	73° 36’ 21.5" N	117° 10’ 38.5" E
Borehole C-2	73°42’ 36.1" N	117° 10’ 01.1" E
Borehole C-3	73° 37’ 56.8" N	117° 10’ 04.4" E
Borehole C-4	73° 36’ 43.9" N	117° 10’ 02.1" E
Borehole C-5	73° 36’ 37.0" N	117° 09’ 59.8" E

Table 5: Time-table of drilling process

Borehole	Date(s)
Borehole C-1	12.-14.04.2005
Boreholes C-2 & C-2a	14.-19.04.2005
Borehole C-3	21.-22.04.2005
Borehole C-4	22.-23.04.2005
Boreholes C-5a, C-5b, C-5c	24.-25.04.2005

Table 6: Timing of borehole temperature measurements

Borehole	Drilling completion	Measurement date		
C-1	14.04.2005	14.04.2005	21.04.2005	25.04.2005
C-2	19.04.2005	20.04.2005	26.04.2005	
C-3	20.04.2005	26.04.2005		
C-4	22.04.2005	26.04.2005		
C-5	25.04.2005	26.04.2005		

Table 7: Overview of the core material recovered on the COAST expedition.

	C-1	C-2	C-3	C-4	C-5
Distance to coast [km]	0.1	11.5	3	1	0.5
Water depth [m]	-	6.0	4.4	2.2	1.5
Ice thickness [m]	-	1.35	1.85	2.1	1.5
Bottom water salinity [‰]	-	29.2	30.0	32.2	> 100
Bottom water temperature [°C]	-	-1.54	-1.61	-1.67	-5 to -7
Frost table depth [m]	0	35	12	3.9	2.8

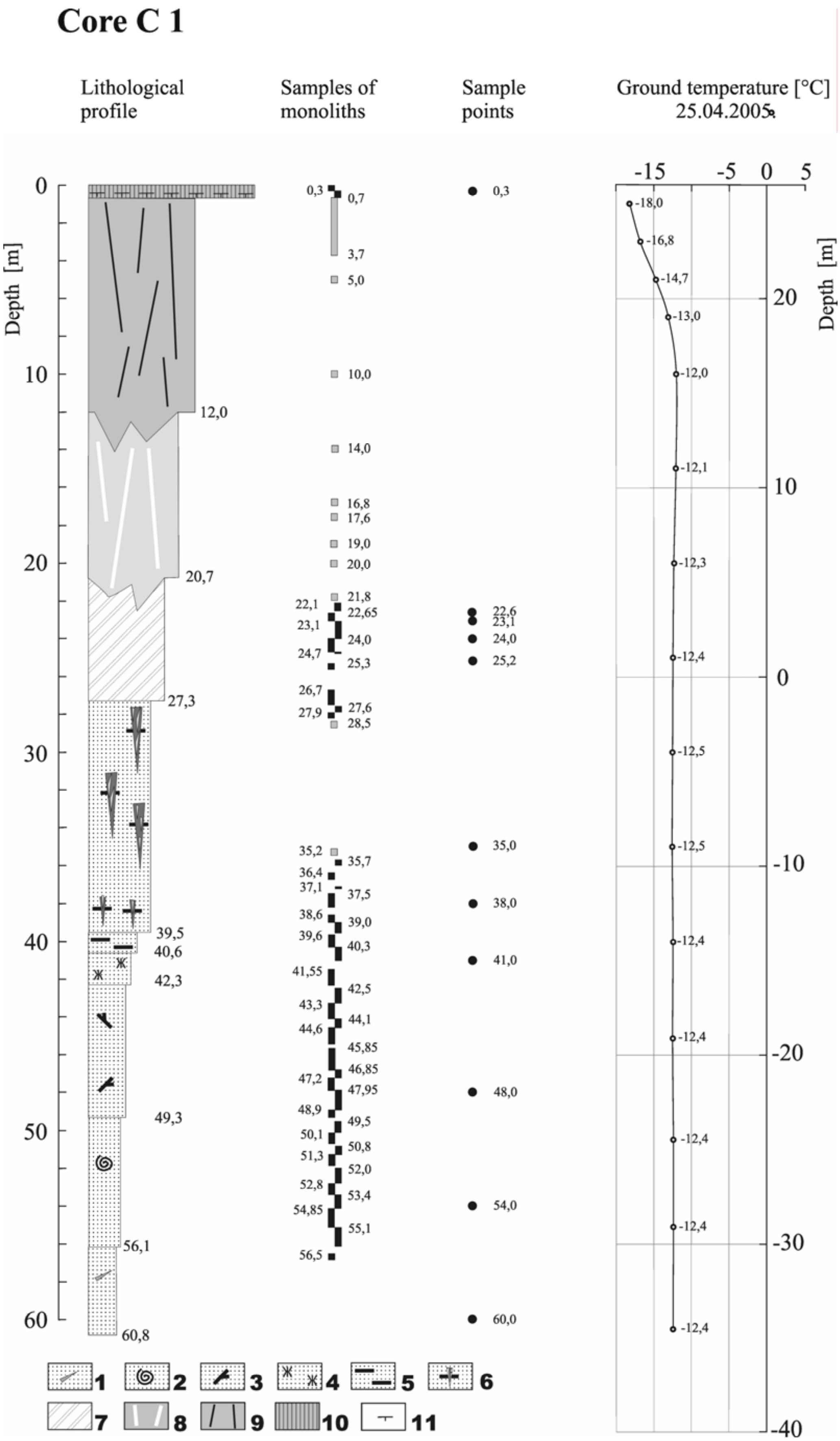

Figure 6: Core C-1 lithology, sample points and temperature profile

Table 8: Legend for the lithological profile of core C-1.

#	Depth [m]	Sediment	Cryotexture
11.		Active layer (seasonally thawing layer) boundary	
10.	0.3-0.7	Loam (clayey-silty and fine sand), dark gray, silty with layers and lenses of dark gray autochthonous peat	0.4-0.7 m lens-like cryotexture; lens-like (upper profile) to network-like
9.	0.7 – 12.7	Ice light gray, ice wedge, layered, with stains of gray and black sediment (mud) with vertical lines of small gas bubbles (1-2 mm)	
8.	2.7 – 20.7	Ice, brownish gray, ice wedge, layered, with vertical lines of small gas bubbles (1-2 mm) and bands of brown sediment	
7.	20.7 – 27.3	Fine sand, light gray, in horizontal and inclined layers; individual horizontal interbeds enriched with grass roots; many roots at the boundary between the lower portion of the gray layer containing spots and streaks– fragments of paleosoil.	Ice-bonded
6.	27.3 – 39.5	Fine sand, light gray,	Interspersed ice layers (1-2 cm); fragments of composite ice wedges (Polosatiki); Ice-bonded
5.	39.5 – 40.6	Mostly fine sand, light gray,	Individual horizontal interbeds of ice (up to 10 cm thick), massive, Ice-bonded
4.	40.6 – 42.3	Sand brownish gray (reddish), fine to medium grain size with horizontal layering.	Massive, ice-bonded.
3.	42.3 – 49.3	Fine sand, dark gray, with interbeds of fine sand, mostly horizontally layered; thin(2 mm) lenses of brown and dark gray plant detritus.	Massive, ice-bonded.
2.	43.3 – 56.1	Fine sand, dark gray, with interbeds of fine sand, mostly horizontal layered, fragments of small thin-walled shells, fine lenses with black organic material (> 49.3 m).	Massive, ice-bonded
1.	56.1 – 60.8	Fine sand, dark gray, with interbeds of fine sand (clayey-silty and fine sand), mostly horizontally layered, individual inclusions of small (3-4 cm) quartz grit (at 57.3 m).	Massive, ice-bonded

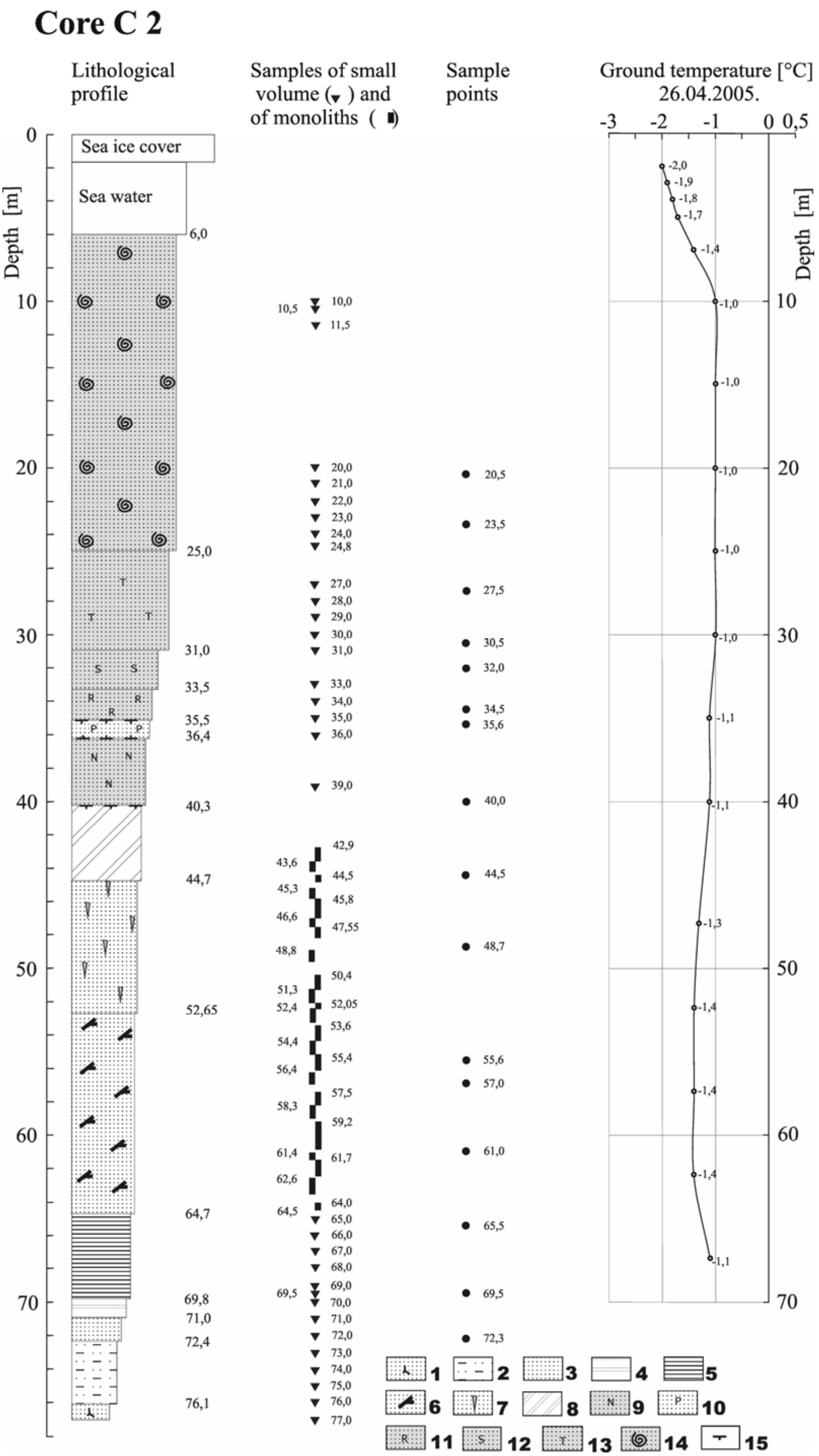

Figure 7: Core C-2 lithology, sample points and temperature profile

Table 9: Legend for the lithological profile of core C-2

no	Depth [m]	Sediment	Cryotexture
15.		The boundary of frozen, ice-bearing sediment; vertical mark is oriented towards the frozen layers	
14.	6.0 – 25.0	Fine sand dark gray, with silty interlayers, lightly compressed, moist, small wood fragments (0.5–5 mm), individual double shells < 2 mm	Unfrozen
13.	25.0 - 31.0	Fine sand dark gray, lightly compressed, moist	Unfrozen
12.	31.0 – 33.5	Fine sand dark gray, thin layers of silty, fine sand, lightly compressed, moist	Unfrozen
11.	33.5 – 35.5	Fine sand, brownish gray thin layers of silty fine sand, dense, moist	Unfrozen
10.	35.5 – 36.4	Silty fine sand, brownish gray (upper), dark gray (lower), small black spots	Frozen, ice-bonded
9.	36.4 – 40.3	Fine sand brownish gray, light (straw yellow), small wood fragments (0.5–5mm), wet and viscous	Unfrozen
8.	40.3 – 44.7	Clayey fine sand, brownish gray, horizontal and inclined layering.	Frozen, ice-bonded
7.	44.7 – 52.65	Fine sand brownish gray, interbeds of light gray: thin almost black lenses of plant remains	Fragments of ice wedges (Polosatiki), ice-bonded, interbeds with lenses – up to network-like (at 49.1–49.3; 49.6–49.7; 49.9–50.2 m) and basal cyrotexture (at 49.0–49.1; 49.7–49.9; 52.4–52.65 m)
6.	52.65 – 64.7	Medium to fine sand, brownish gray, horizontal and inclined layering; interbeds of alluvial peat (at 62.1 – 62.3m), scattered fragments of thin twigs and wood detritus.	Ice-bonded, individual small ice lenses bordering on wood remains
5.	64.7 – 69.8	Dark gray loam, clay, individual fine sand layers	Frozen, ice-bonded
4.	69.8 – 71.0	Silty fine sand , dark gray, loamy interbeds	Frozen, ice-bonded
3.	71.0 – 72.4	Fine sand, brownish gray, thin silt interbeds	Frozen, ice-bonded
2.	72.4 – 76.1	Silty fine sand (Aleurit) dark gray, with loamy and fine sand interlayers; gravel (D 1 cm) at 75.5 m depth	Ice-bonded (?)
1.	76.1 – 77.0 (0.9 m)	Fine sand, brownish gray, gray-blue sand-interbeds with horizontal layering	Frozen, ice-bonded

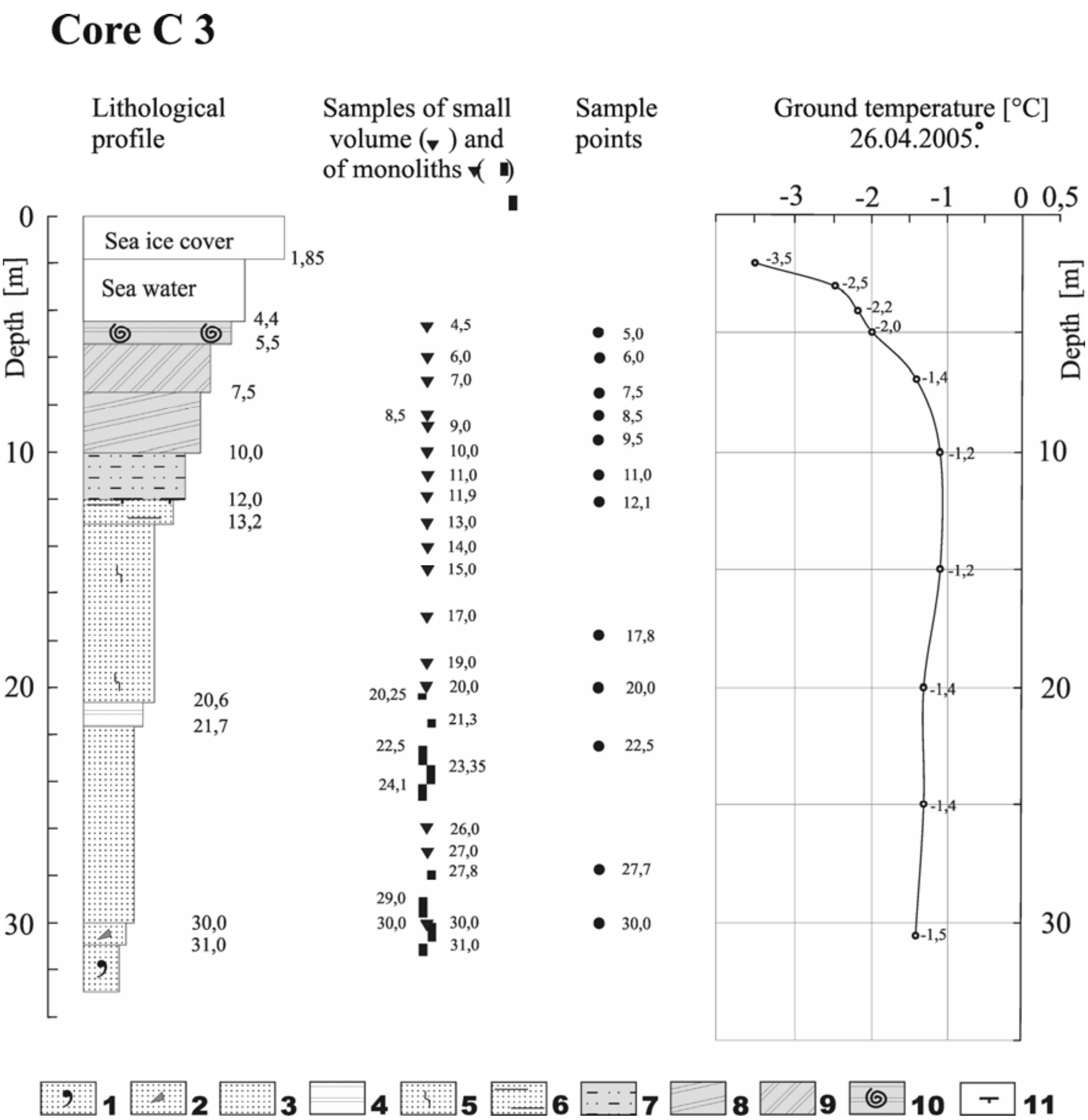

Figure 8: Core C-3 lithology, sample points and temperature profile

Table 10. Legend for the lithological profile of core C-3

no	Depth [m]	Sediment	Cryotexture
11.		Permafrost boundary	
10..	4.4 – 5.5	Aleurit dark gray, almost black, inclusions of plant detritus, fragments and complete specimens of double shells, lightly compressed, wet	Unfrozen
9.	5.5 – 7.5	Aleurit, dark gray, layered, interbeds of brownish gray aleurit, denser than overlying sediment, wet	Unfrozen
8.	7.5 – 10.0	Aleurit brownish gray, layered, sand interbeds and black aleurit, thin lenses (1-2 mm) and small inclusions (up to 3 cm) of plant detritus, wet	Unfrozen
7.	10.0 – 12.0	Fine sand, brownish gray, interbeds of dark gray aleurit, thin (1-2 mm) lenses of plat detritus, and individual small peat inclusions (up to 2 cm), moss and grass remains, wet	Unfrozen
6.	12.0 – 13.2	Fine sand, somewhat silty, brownish/blueish gray, small sparse plant remains	Frozen, ice-bonded
5.	13.2 – 20.6	Fine sand, dark gray fine-grained, and thin-grained, mostly horizontally layered, individual roots (at 15.4 -17.8 m), small peat inclusions (at 13.2 – 15.4 m and 19.6 – 20.6 m)	Frozen, ice-bonded
4.	20.6 – 21.7	Fine sand light gray, brownish gray in places, horizontal layering	Frozen, ice-bonded
3.	21.7 – 30.0	Fine sand light gray, horizontal layering, aleurit interbeds (transforms into quicksand on melting)	Frozen, ice-bonded
2.	30.0 – 31.0	Fine sand gray, layered, individual quartz gravel and pebbles (up to 2 cm)	Frozen, ice-bonded
1.	31.0 – 33.25 thickness 2.25 m	Fine sand gray, layered, small peat inclusions (up to 1 cm), black sulphide spots	Frozen, ice-bonded

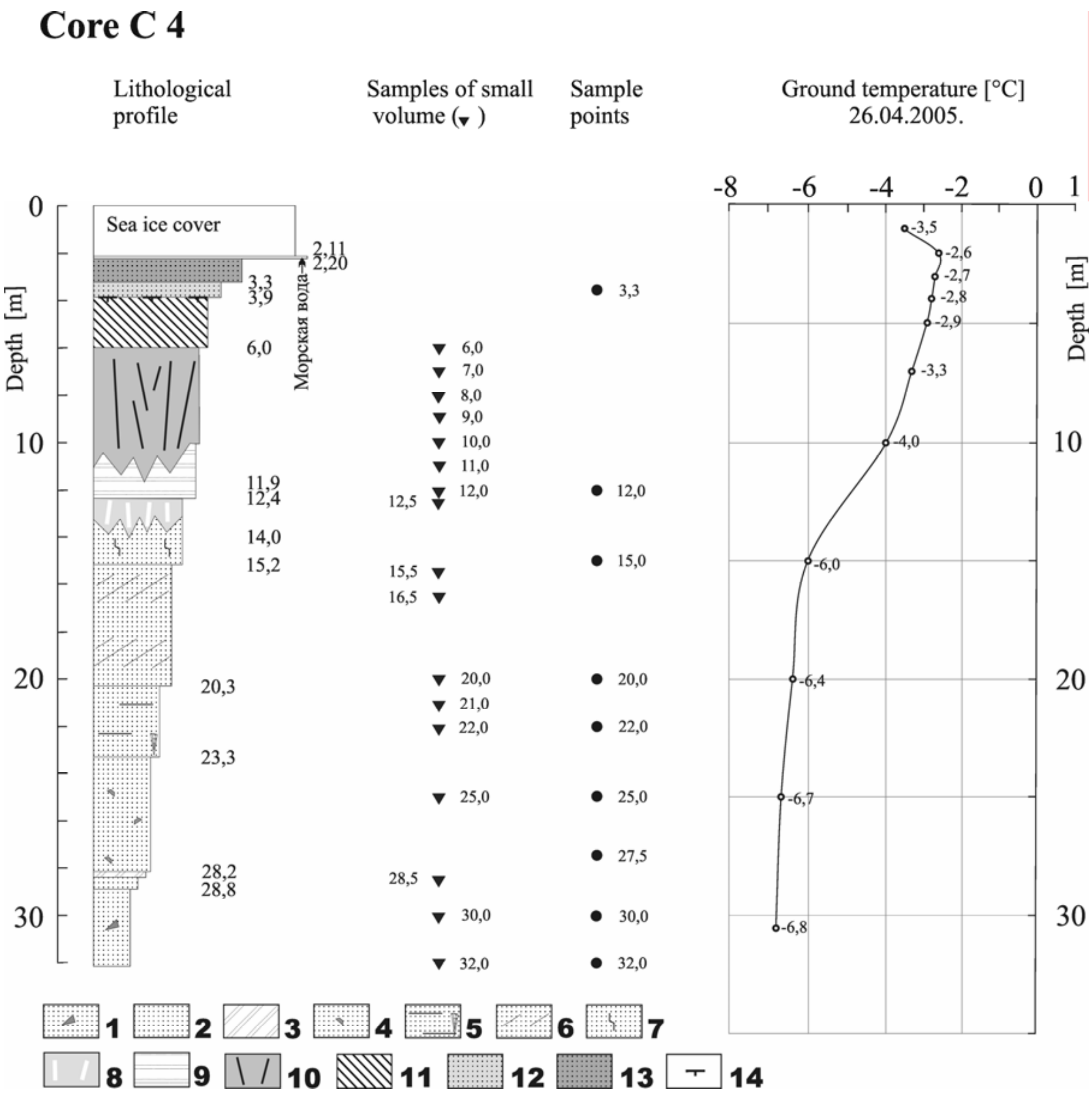

Figure 9: Core C-4 lithology, sample points and temperature profile

Table 11: Legend for the lithological profile of core C-4

no	Depth [m]	Sediment	Cryotexture
14.		Permafrost boundary	
13.	2.2 – 3.3	Fine sand dark gray, silty, with individual interbeds of gray sand and inclusions of dark spots and of fine plant detritus	Unfrozen
12.	3.3 -3.9	Fine sand, brownish gray, inclusions of plant remains	Unfrozen
11.	3.9 -6.0	Loam, dark gray, with inclusions of plant remains (detritus), dense.	Frozen, ice-cemented
10.	6.0 – 11.9		Ice, gray and opaque, vertically striped, ice wedge with gas bubbles and individual bands of brown and gray silt.
9.	11.9 – 12.4	Fine sand, silty, dark gray, horizontally layered.	contains roots of ice wedges, ice-cemented
8.	12.4 – 14.0		Ice wedge, yellowish gray, vertically striped, with gas bubbles and with many brown silt and sand stripes (Polosatik).
7.	14.0 – 15.2	Fine sand, silty, green-gray, horizontally layered	Frozen, ice-cemented
6.	15.2 – 20.3	Fine sand brownish gray, with horizontal and inclined layers with individual thin interbeds of aleurit and brown plant detritus (up to 3 mm).	Frozen, ice-cemented
5.	20.3 – 23.3	Fine sand, brownish gray and dark gray, mostly horizontally layered, individual interbeds of aleurit and small inclusions and lenses of grass-moss-peat (at 20.8 – 21.6 m)	Individual narrow sand-ice veins; ice wedges (Polosa-tiki), ice-cemented
4.	23.3– 28.2	Sand light gray, dark sulphide spots (at 23.3 – 24.0 m); brownish gray fine sand with occasional gravel	Frozen, ice-cemented
3.	28.2 – 28.6	Aleurit, (black, sand interbeds, frequent inclusions of plant detritus	Ice-cemented, thin ice stripes
2.	28.6 – 28.8	Fine to medium sand, gray, individual horizontal brown sand layers	Frozen, ice-cemented
1.	28.8 – 32.1	Fine sand brownish gray, individual gravel inclusions; thickness 2.1 m	Frozen, ice-cemented

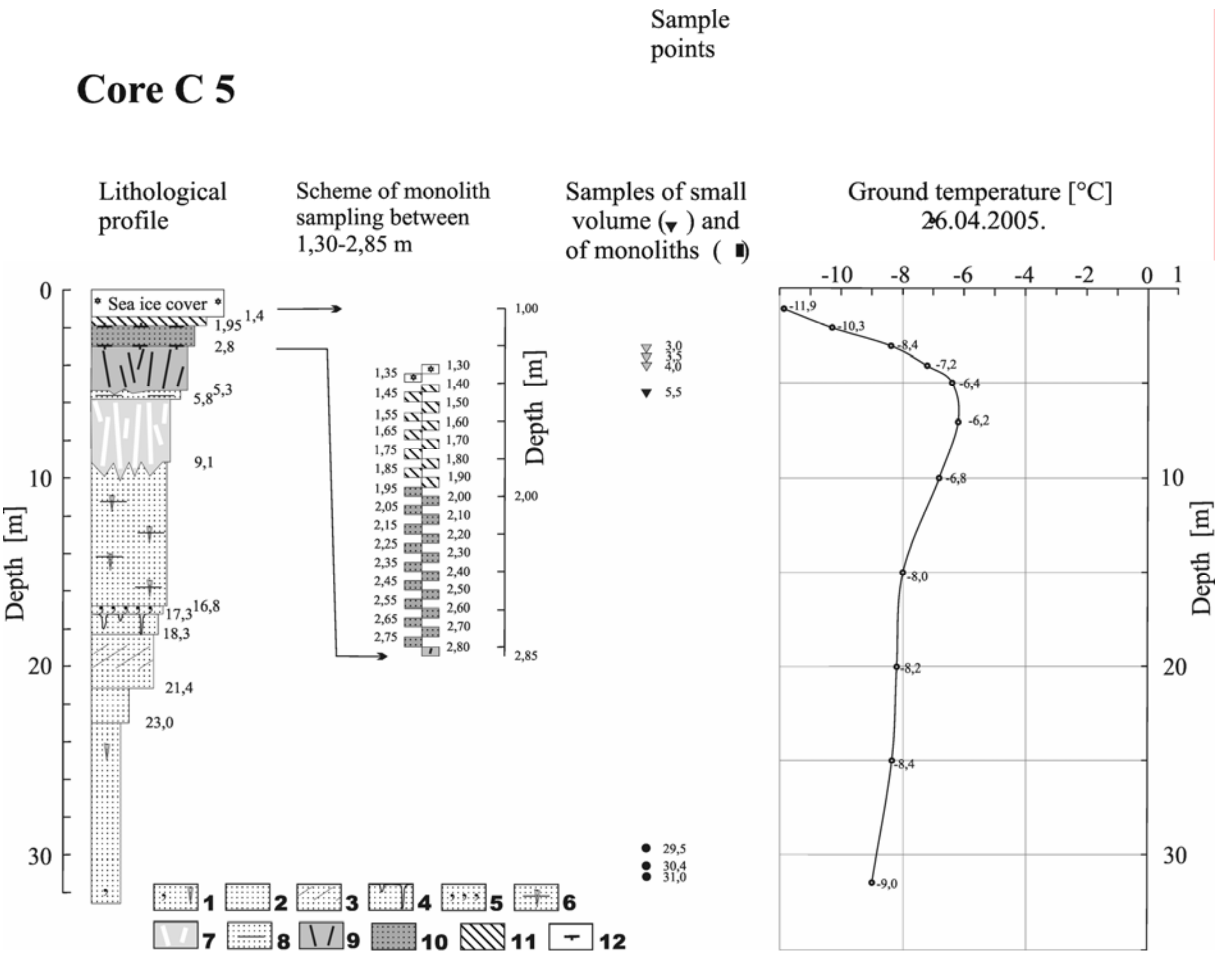

Figure 10: Core C-5 lithology, sample points and temperature profile

Table 12. Legend for the lithological profile of core C-5

no	Depth [m]	Sediment	Cryotexture
12.		Permafrost boundary	
11.	1.4 – 1.95	Aleurit dark gray	Frozen, ice-bonded
10.	1.95 – 2.8	Fine sand dark gray, with aleurit,	Unfrozen, wet
9.	2.8 – 5.3		Ice wedge brownish gray, vertically striped, with Gas bubbles and small admixtures of brown silt.
8.	5.3 – 5.8	Fine sand brownish gray, silty interbeds	Ffrozen, ice-bonded
7.	5.8 – 9.1		Ice wedge yellowish gray, vertically striped, with gas bubbles; stripes of brown fine sand (Polosatik)
6.	9.1 – 16.8	Fine sand, dark gray to brownish gray, mostly horizontally layered, individual interbeds (up to 1 cm) of aleurit.	Frozen, ice-bonded individual layers with bands of ice (at12.2 – 12.8 m), fragments of sand–ice–veins (Polosatiki) (at 9.1– 10 m; 13.7–14.5 m)
5.	16.8 – 17.3	Fine sand brown, with plant detritus (sandy peat) of grass and moss remains.	Frozen, ice-bonded
4.	17.3 – 18.3	Fine sand light gray, layered at an incline, with brown streaks of the base of the overlying layer.	Frozen, ice-bonded
3.	18.3 – 21.4	Fine to medium sand, light gray, in horizontal and inclined layers; thin inclined lenses (1– 3 mm) of fine (powder-like) plant detritus	Frozen, ice-bonded
2.	21.4 – 23.0	Fine sand brownish gray, horizontally layered	Frozen, ice-bonded
1.	23.0 – 32.5	Fine sand, brownish-bluish gray, with sulphide spots, individual interbeds of aleurit and a few thin (up to 0.2 m) lenses of alluvial peat (at 31.9 – 32.1 m), horizontally layered.. Thickness: 9.5 m	Frozen, ice-bonded network-like cryogenic texture in the upper portion (at 23.0 – 23.3 m); few vertical ice veins (at 24.1 – 26.0 m)

The subsequent 4 cores were drilled from the sea ice through submarine and ancient terrestrial deposits. The core located furthest from the coastline (Core 2 at 11.5 km from the coast) was drilled in approximately 6 m water depth with a sea ice thickness of 1.35 m. The shallow water is a reflection of the shallowness of the offshore coastal shelf in general in this region. At a depth of approximately 35 m below sea level core 2 encountered frozen submarine material (Figure 5), although, as shown later, most of the core had temperatures of less than 0 °C. Between cores C-1 and C-2 additional cores were recovered. An overview of their distribution and depths is shown in Tables 4 to 7.

Core material recovery rates were not 100% for all five cores. For additional reasons, existing sample material falls short of the total recovered material (about 240 m):

- part of the sub-sea unfrozen core was lost during drilling, sampling and processing due to its viscosity;
- part of the sub-sea unfrozen and frozen core was used for field analysis of cryogenesis and pore water chemistry. In the latter case, pressed and dried sediment was recovered and retained;
- part of the frozen core was composed of ice-wedge material that was destroyed and mixed in the well tube/core barrel on drilling, a common problem for this type of material;
- part of the contiguously frozen cores between boreholes C-3 and C-5, which were located quite close to each other, was sampled at intervals instead of completely in order to save on shipping and analyses.

The total weight of core material shipped from the field was about 1 ton. A portion of the core material (about 100 kg) was transported to AARI (St.-Petersburg). The rest of the frozen sediments were packed for transport immediately after being described lithologically and geocryologically. They were shipped frozen to Bremerhaven, Germany and archived there. Unfrozen core sections were divided into sub-samples in the field, which were then also frozen for shipping.

3.2 Pore water analyses

Some sub-samples from the unfrozen core sections were used for field analysis of pore water chemistry. Pore water was pressed from the sediments using nitrogen (Figure 11). Extracted pore water volumes varied between 2 and 15 ml per sample. These samples were collected for major cation and anion analyses in the laboratory of AWI, Potsdam using inductively coupled plasma optical emission spectroscopy (ICP-OES) and gas chromatography, respectively. The salinity reported here was calculated based on sample Cl^- and Na^+ concentrations.

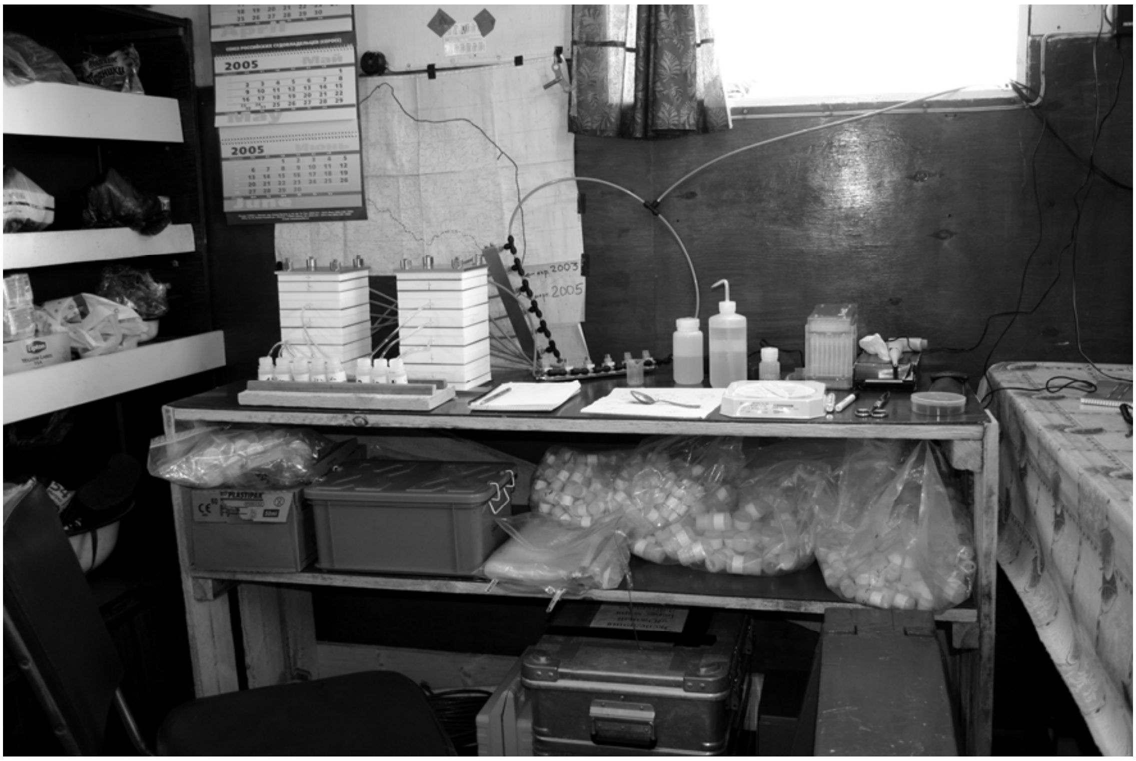

Figure 11: Pore water press in use in the field to extract sediment pore water

Figure 12: Detail photograph of core C-2 taken in the field. Although recovered from a submarine environment, ice-rich, terrestrial cryogenic structures are visible, indicating the occurrence marine transgression and/or coastal erosion

The salinity results clearly show that relict terrestrial permafrost continues over the near-shore range of the Laptev Sea continental shelf and is present there as submarine permafrost. Frozen sediments were found in all marine cores, with geocryological characteristics corresponding to those of the terrestrial permafrost encountered in core C-1. Figure 12 shows a photograph of a section of core C-2, originating from a depth of approximately 40 m below sea level. The terrestrial origin of the material's geocryological texture is corroborated by the chemical and isotope composition of the pore ice, which also correspond to those of the terrestrial permafrost of core C-1 as well as additional samples of the coastal section sampled in 2003.

Results of pore water analyses together with lithological profiles are represented in figures 13 and 14. Bottom water salinities of cores C-2 to C-4 are clearly marine and continue into the pore water of the unfrozen sediments. Pore water salinity decreases with the transition from unfrozen to frozen material, reaching almost fresh water conditions in the latter.

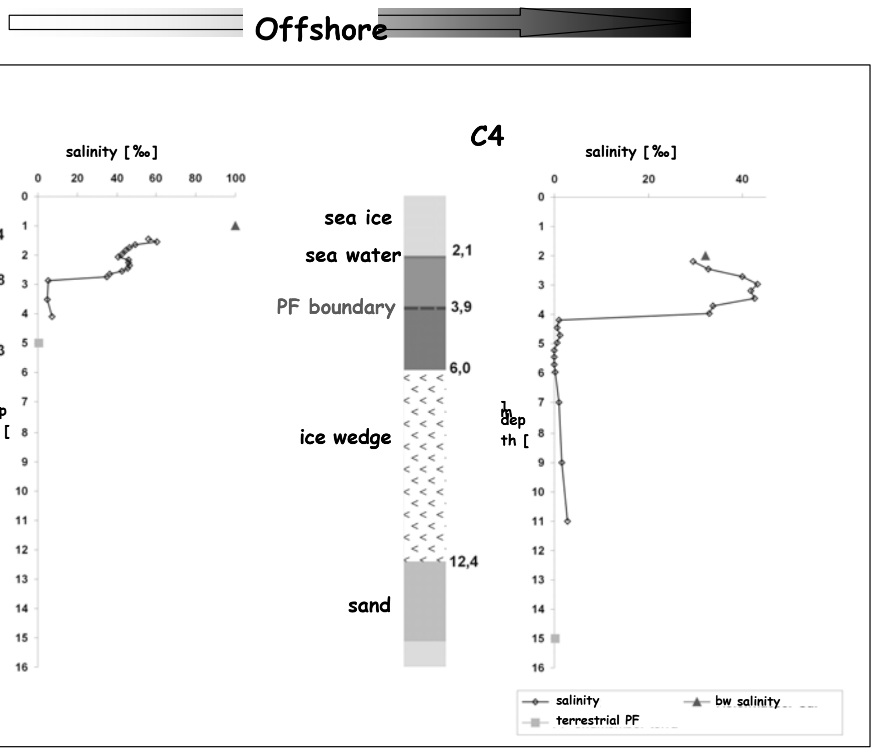

Figure 13: Lithology and salinity profiles of the cores C-4 and C-5. The position of the ice-bonded sediment table is indicated by a dashed line. The triangle marks the salinity of the bottom water and the square the salinity of the terrestrial permafrost pore water (measured in terrestrial permafrost at the Cape Mamontov Klyk).

Core 5 presents an exception in that no liquid seawater was present between the sea ice and the frozen sediment. With a total water depth 1.5 m, the sea ice lay directly on the sea bottom and was frozen to the sediment. However, water with a salinity of more than 100‰ and temperatures in the range -5 to -7 °C exuded from a number of drillings made in the region of core C-5. Ice formation results in the exclusion of salts from the freezing solution and the resultant concentration of salts in the residual solution (brine). As a result, a 1 m thick layer of unfrozen sediment was encountered directly beneath the sea ice (Figure 10, 13, Table 12). The term submarine cryopeg is applied to this layer.

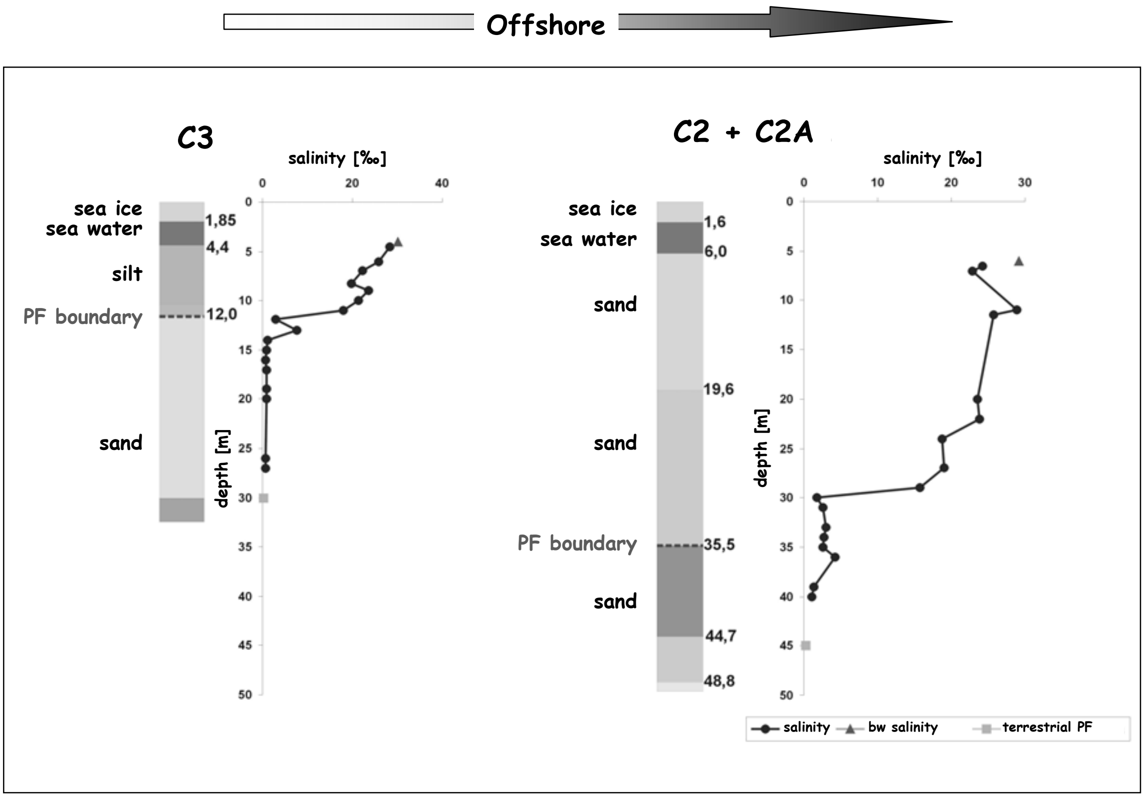

Figure 14: Lithology and salinity profiles of the cores C-2 and C-3. The position of the ice-bonded sediment table is indicated. The triangle marks the salinity of the bottom water and the square the salinity of the terrestrial permafrost pore water (measured in terrestrial permafrost at the Cape Mamontov Klyk).

The most interesting result of the drilling campaign was found in the lower section of Core 2. The lower limit of frozen material was reached at 65 m below sea level, below which an unfrozen layer was encountered (Fig 4). According to published models of permafrost distribution, permafrost thickness within the coastal range lies in the hundreds of meters. The sedimentology and pore water salinity suggest that the underlying unfrozen material is composed of marine sediments. The marine salinity levels result in an unfrozen state despite temperatures from -1 to -1.5 °C.

3.3 Temperature profiles

The thermal state of the sediment was measured at each borehole using two methods. The first method was based on resistance measurements of calibrated thermistors (MMT-4). The second device was a newly developed non-contact (infrared) temperature sensor. Measurements were made from 1 to 11 days after drilling. Both methods were used at C-1 and C-2 to compare results. To allow for equilibration of the temperature field after drilling, temperature profiles were measured at the end of the drilling campaign in boreholes C-1, C-3 and C-5, using the infrared method. Water infiltrated the other boreholes, preventing use of the infrared method at the end of the campaign.

The most prominent feature of the temperature data is the quick equilibration of submarine permafrost to the sea-water temperature (-1.5°C) and the rapid degradation that this implies. Borehole C-3 is located approximately 2500 meters off shore, which represents submergence at the local rate of coastal retreat of some 600 years before present using an estimated coastal retreat of 4 m yr^{-1}. After this short period of time the freshwater pore ice in the submarine permafrost is very close to its melting point and therefore pore water salinity becomes more important to determine the presence of ice in the submarine sediments.

Furthermore, the occurrence of unfrozen sediments in the near-shore area due to high pore water salinity and sediment temperatures raises the question whether submarine permafrost can have been preserved throughout the vast areas of the Laptev Sea shelf since last transgression.

4. Sample lists

Table 13. Sediment sample list. Field descriptions integrated in this list distinguish only the presence or absence of ice wedges. Many samples are labeled with a single depth only; in general, these are samples which are not included in the AWI sample set, which total 54 m of sediment material from the total 235.55 m of drilled sediment depth.

Sample Number	Core Number	Upper Depth	Lower Depth	Description
1	C-1	0.00	0.30	sediment
2	C-1	0.32	0.70	sediment
3	C-1	0.70	3.70	sediment with ice wedges
4	C-1		5.00	sediment with ice wedges
5	C-1		10.00	sediment with ice wedges
6	C-1		14.00	sediment with ice wedges
7	C-1		16.80	sediment with ice wedges
8	C-1		17.60	sediment with ice wedges
9	C-1		19.00	sediment with ice wedges
10	C-1		20.00	sediment with ice wedges
11	C-1		21.80	sediment with ice wedges
12	C-1	22.10	22.60	sediment
13	C-1	22.65	23.10	sediment
14	C-1	23.10	24.00	sediment
15	C-1	24.00	24.70	sediment
16	C-1	24.70	24.75	sediment
17	C-1	25.30	25.60	sediment
18	C-1	26.70	27.50	sediment
19	C-1	27.60	27.90	sediment
20	C-1	27.90	28.20	sediment with ice layer
21	C-1		30.30	sediment with ice wedges
22	C-1		35.20	sediment with ice wedges
23	C-1	35.70	36.00	sediment
24	C-1	36.40	36.70	sediment
25	C-1	37.10	37.20	ice-rich sediment
26	C-1	37.50	38.20	sediment
27	C-1	38.60	39.00	sediment
28	C-1	39.00	39.50	sediment
29	C-1	39.60	40.30	sediment
30	C-1	40.30	41.00	sediment
31	C-1	41.55	42.30	sediment
32	C-1	42.50	43.30	sediment
33	C-1	43.30	44.10	sediment
34	C-1	44.10	44.60	sediment

Table 13. Continuation

Sample Number	Core Number	Upper Depth	Lower Depth	Description
35	C-1	44.60	45.50	sediment
36	C-1	45.85	46.85	sediment
37	C-1	46.85	47.20	sediment
38	C-1	47.20	47.95	sediment
39	C-1	47.95	48.90	sediment
40	C-1	48.90	49.30	sediment
41	C-1	49.50	50.10	sediment
42	C-1	50.10	50.70	sediment
43	C-1	50.80	51.30	sediment
44	C-1	51.30	51.90	sediment
45	C-1	52.00	52.80	sediment
46	C-1	52.80	53.40	sediment
47	C-1	53.40	54.10	sediment
48	C-1	54.85	55.10	sediment
49	C-1	55.10	56.10	sediment
50	C-1	56.50	56.80	sediment
51	C-1	56.80	57.70	sediment
52	C-1	57.80	58.50	sediment
53	C-1	58.55	59.30	sediment
54	C-1	59.35	60.00	sediment
55	C-1	60.00	60.80	sediment
30	C-2A		6.00	sediment
31	C-2A		6.50	sediment
32	C-2A		7.00	sediment
54	C-2A		6.00	sediment
55	C-2A		6.50	sediment
56	C-2A		7.00	sediment
33	C-2A		11.50	sediment
56	C-2A		11.50	sediment
32	C-2		10.00	sediment
33	C-2		10.50	sediment
5	C-2		10.50	sediment
6	C-2		11.50	sediment
7	C-2		11.50	sediment
38	C-2		20.00	sediment
9	C-2		20.00	sediment
10	C-2		21.00	sediment
11	C-2		21.00	sediment
12	C-2		22.00	sediment

Table 13: Continuation

Sample Number	Core Number	Upper Depth	Lower Depth	Description
13	C-2		22.00	sediment
14	C-2		23.00	sediment
15	C-2		23.00	sediment
16	C-2		24.00	sediment
17	C-2		24.00	sediment
18	C-2		24.80	sediment
19	C-2		24.80	sediment
20	C-2		27.00	sediment
21	C-2		27.00	sediment
22	C-2		28.00	sediment
23	C-2		28.00	sediment
24	C-2		29.00	sediment
25	C-2		29.00	sediment
26	C-2		30.00	sediment
27	C-2		30.00	sediment
28	C-2		31.00	sediment
29	C-2		31.00	sediment
30	C-2		33.00	sediment
31	C-2		33.00	sediment
32	C-2		34.00	sediment
33	C-2		34.00	sediment
34	C-2		35.00	sediment
35	C-2		35.00	sediment
36	C-2		36.00	sediment
37	C-2		36.00	sediment
38	C-2		39.00	sediment
39	C-2		39.00	sediment
32	C-2	40.00	40.30	sediment
33	C-2	40.30	41.00	sediment
34	C-2	41.10	41.90	sediment
35	C-2	42.10	42.70	sediment
36	C-2	42.90	43.50	sediment
37	C-2	43.60	44.20	sediment
38	C-2	44.50	44.80	sediment
39	C-2	45.30	45.80	sediment
40	C-2	45.80	46.60	sediment
41	C-2	46.60	47.55	sediment
42	C-2	47.55	48.25	sediment
43	C-2	48.80	49.60	sediment

Table 13: Continuation

Sample Number	Core Number	Upper Depth	Lower Depth	Description
44	C-2	50.40	51.30	sediment
45	C-2	51.30	52.05	sediment
46	C-2	52.05	52.40	sediment
47	C-2	52.40	53.40	sediment
48	C-2	53.60	54.40	sediment
49	C-2	54.40	55.40	sediment
50	C-2	55.40	56.20	sediment
51	C-2	56.40	57.20	sediment
52	C-2	57.50	58.30	sediment
53	C-2	58.30	59.10	sediment
54	C-2	59.20	61.10	sediment
55	C-2	61.40	61.70	sediment
56	C-2	61.70	62.50	sediment
57	C-2	62.60	63.50	sediment
58	C-2	64.00	64.50	sediment
59	C-2		65.00	sediment
60	C-2		65.00	sediment
61	C-2		66.00	sediment
62	C-2		66.00	sediment
63	C-2		67.00	sediment
64	C-2		67.00	sediment
65	C-2		68.00	sediment
66	C-2		68.00	sediment
67	C-2		69.50	sediment
68	C-2		69.50	sediment
69	C-2		70.00	sediment
70	C-2		70.00	sediment
71	C-2		71.00	sediment
72	C-2		71.00	sediment
73	C-2		72.00	sediment
74	C-2		72.00	sediment
75	C-2		73.00	sediment
76	C-2		73.00	sediment
77	C-2		74.00	sediment
78	C-2		74.00	sediment
79	C-2		75.00	sediment
80	C-2		75.00	sediment
81	C-2		76.00	sediment
82	C-2		76.00	sediment

Table 13: Continuation

Sample Number	Core Number	Upper Depth	Lower Depth	Description
83	C-2		77.00	sediment
84	C-2		77.00	sediment
85	C-3		4.50	sediment
86	C-3		6.00	sediment
87	C-3		7.00	sediment
88	C-3		8.50	sediment
89	C-3		9.00	sediment
90	C-3		10.00	sediment
91	C-3		11.00	sediment
92	C-3		11.90	sediment
93	C-3		13.00	sediment
94	C-3		14.00	sediment
95	C-3		15.00	sediment
96	C-3		17.00	sediment
97	C-3		19.00	sediment
98	C-3		20.00	sediment
99	C-3	20.25	20.60	sediment
100	C-3	21.30	21.70	sediment
101	C-3	22.50	23.35	sediment
102	C-3	23.35	24.10	sediment
103	C-3	24.10	24.80	sediment
104	C-3		26.00	sediment
105	C-3		27.00	sediment
106	C-3	27.80	28.30	sediment
107	C-3	29.00	29.80	sediment
108	C-3		30.00	sediment
109	C-3	30.20	30.90	sediment
110	C-3	31.00	31.50	sediment
111	C-3		4.50	sediment
112	C-3		6.00	sediment
113	C-3		7.00	sediment
114	C-3		8.50	sediment
115	C-3		9.00	sediment
116	C-3		10.00	sediment
117	C-3		11.00	sediment
118	C-3		11.90	sediment
119	C-3		13.00	sediment
120	C-3		14.00	sediment
121	C-3		15.00	sediment

Table 13: Continuation

Sample Number	Core Number	Upper Depth	Lower Depth	Description
122	C-3		17.00	sediment
123	C-3		19.00	sediment
124	C-3		20.00	sediment
125	C-3		26.00	sediment
126	C-3		27.00	sediment
127	C-3		30.00	sediment
128	C-4		6.00	sediment
129	C-4		7.00	sediment
130	C-4		8.00	sediment
131	C-4		9.00	sediment
132	C-4		10.00	sediment
133	C-4		11.00	sediment
134	C-4		12.00	sediment
135	C-4		12.50	sediment
136	C-4		15.50	sediment
137	C-4		16.50	sediment
138	C-4		20.00	sediment
139	C-4		21.00	sediment
140	C-4		22.00	sediment
141	C-4		25.00	sediment
142	C-4		28.50	sediment
143	C-4		30.00	sediment
144	C-4		32.00	sediment
145	C-4		12.00	sediment
146	C-4		15.50	sediment
147	C-4		16.50	sediment
148	C-4		20.00	sediment
149	C-4		21.00	sediment
150	C-4		22.00	sediment
151	C-4		25.00	sediment
152	C-4		28.50	sediment
153	C-4		30.00	sediment
154	C-4		32.00	sediment
155	C-5	1.50	1.55	sediment
156	C-5	1.60	1.65	sediment
157	C-5	1.70	1.75	sediment
158	C-5	1.80	1.85	sediment
159	C-5	1.90	1.95	sediment
160	C-5	2.00	2.05	sediment

161	C-5	2.10	2.15	sediment
162	C-5	2.20	2.25	sediment
163	C-5	2.30	2.35	sediment
164	C-5	2.40	2.45	sediment
165	C-5	2.50	2.55	sediment
166	C-5	2.60	2.65	sediment
167	C-5	2.70	2.75	sediment
168	C-5	2.80	2.85	sediment
169	C-5	2.90	2.95	sediment
170	C-5		3.00	sediment with ice wedges
171	C-5		5.50	sediment with ice wedges

Table 14. Pore water samples recovered hydraulically from cored sediments in the field, with field-determined salinities.

Core	Depth [m]	Cations [10 ml]	Anions [15 lL]	Isotopes [30 ml]	Sediment Cakes [100 g]	Remarks	Salinity [mS/cm]	Volume [ml]
C-2	11	x	x		x			10
C-2	20	x	x		x			10
C-2	22	x	x		x			11
C-2	24	x	x		x			6
C-2	27	x	x		x			8
C-2	28				x			0
C-2	29	x	x		x			5
C-2	30	x	x		x			12
C-2	31	x	x		x			7
C-2	33	x			x			3
C-2	34	x	x		x			13
C-2	35	x	x		x	frozen	3.9	17
C-2	36	x	x		x	frozen		7
C-2	39	x			x	frozen		4
C-2	40	x	x		x	frozen		4
C-2	42			x	x	frozen	1.2	
C-2	43.5			x	x	frozen	0.9	
C-2	66-68					unfrozen mud	16.1	
C-2A	6				x			0
C-2A	6.5	x			x			3
C-2A	7	x	x					8
C-2A	11.5	x	x		x			5
C-3	4.5	x			x			3
C-3	6	x			x			2
C-3	7	x	x		x	brown		5
C-3	8.3	x			x			2
C-3	8.5				x			0
C-3	9	x			x			2
C-3	10	x			x			3
C-3	11	x	x		x	brown		12
C-3	11.9	x	x		x	frozen	3.8	8
C-3	13	x			x	frozen		4
C-3	14	x	x		x	frozen		7
C-3	15	x	x		x	frozen		14
C-3	16	x	x		x	frozen		10
C-3	17	x	x		x	frozen		13
C-3	19	x	x		x	frozen		21

Table 14: Continuation

Core	Depth [m]	Cations [10 ml]	Anions [15 lL]	Isotopes [30 ml]	Sediment Cakes [100 g]	Remarks	Salinity [mS/cm]	Volume [ml]
C-3	20	x	x		x	frozen		19
C-3	26	x	x		x	frozen		8
C-3	27	x	x		x	frozen		6
C-4	0+2.2	x	x		x			15
C-4	0.25+2.2	x	x		x			12
C-4	0.5+2.2	x	x		x			8
C-4	0.75+2.2	x			x			3
C-4	1+2.2	x			x			2
C-4	1.25+2.2	x			x			1.5
C-4	1.5+2.2	x			x			1
C-4	1.75+2.2	x			x			3
C-4	2+2.2	x	x	x		frozen/ice		
C-4	2.25+2.2	x	x	x		frozen/ice		
C-4	2.5+2.2	x	x	x		frozen/ice		
C-4	2.75+2.2	x	x	x		frozen/ice		
C-4	3+2.2	x	x	x		frozen/ice		
C-4	3.25+2.2	x	x	x		frozen/ice		
C-4	3.5+2.2	x	x	x		frozen/ice		
C-4	3.75+2.2	x	x	x		frozen/ice		
C-4	7	x	x	x		frozen/ice		
C-4	9	x	x	x		frozen/ice		
C-4	11	x	x	x		frozen/ice		
C-5	1.45	x	x		x			8
C-5	1.55	x	x		x			10
C-5	1.65	x	x		x			8
C-5	1.75	x	x		x			8
C-5	1.85	x	x		x			16
C-5	1.95	x	x		x			6
C-5	2.05	x	x		x			8
C-5	2.15	x	x		x			10
C-5	2.25	x	x		x			11
C-5	2.35	x	x		x			7
C-5	2.45	x	x		x			8
C-5	2.55	x	x		x			11

Table 14: Continuation

Core	Depth [m]	Cations [10 ml]	Anions [15 lL]	Isotopes [30 ml]	Sediment Cakes [100 g]	Remarks	Salinity [mS/cm]	Volume [ml]
C-5	2.65	x	x		x			9
C-5	2.75	x	x		x			14
C-5	2.85-2.90	x	x	x		frozen/ice		
C-5	3.5	x	x	x		frozen/ice		
C-5	4.1	x	x	x		frozen/ice		

5. References

Antipina Z.N., Are F.E., Voychenko V.V. (1981): Cryolithozone of the Arctic shelf of Eurasia. In: Late Quaternary history and sedimentation of the external and interior seas. Moscow, MSU Press, Russia, p. 47-60 (in Russian).

Fartyshev A.I. (1993): Peculiarities of near-shore and shelf cryolithozone on the Laptev Sea shelf. Novosibirsk, Nayka Press, 135 p. (in Russian).

Grigoriev N.F. (1966): Permafrost in the Yakutian Coastal Zone. Nauka Press, Moscow, 180 pp. (in Russian).

Plakht I.R. (1981) Development of cryogenic sediments in the Laptev Sea shallow shelf zone according to paleogeographical data. In: The cryolithozone of the Arctic shelf. Yakutsk, Russia, p. 62-70 (in Russian).

Ponomarev V.M. (1950): Forming of groundwater on the coast of the Northern Seas and in Permafrost zone. Moscow, AN USSR Press, Russia, 96 p. (in Russian).

Romanov V. P., Kunitsky V.V. (1985): The methods of a permafrost genesis determination (by the example of Muostakh Island). In: Cryohygrogeological investigations. Yakutsk, Permafrost Institute Press, p. 161-166.

Schirrmeister, L.; Grigoriev, M.N.; Kutzbach, L.; wagner, D., Bol'shiyanov, D.Yu. (2004) Russian-German Cooperation SYSTEM LAPTEV SEA: The Expedition Lena-Anabar 2004. Reports on Polar and Marine Research 489.

Soloviev V.A. (1981): Prediction of the distribution of relict submarine frozen zone (on the example of Arctic basin. In: The cryolithozone of the Arctic shelf. Yakutsk, Russia, p. 28-38 (in Russian).

Telepnev E.V. (1981): Sub-sea frozen zone of the near-shore part of the Big Lyakhovsky Island. In: Cryolithozone of the Arctic shelf. Permafrost Institute SB RAS, Yakutsk, Russia, p. 44- 53 (in Russian).

Zhigarev L.A. (1981): Regularities of development of the Arctic Basin cryolithozone. In: Cryolithozone of the Arctic shelf. Yakutsk, Permafrost Institute RAS, p. 4--17 (in Russian).

Russian-German Cooperation SYSTEM LAPTEV SEA:

The Expedition Lena- 2005

by the participants of the expedition

edited by Lutz Schirrmeister and Dirk Wagner,

Mikhail N. Grigoriev, Dimitry Yu. Bolshiyanov

Contents

The Expedition Lena 2005

1. Introduction

Lutz Schirrmeister and Mikhail N. Grigoriev

The purpose of the expedition LENA 2005 was to fill gaps of knowledge and to answer scientific questions that arose during former expeditions. Additionally, the monitoring program based at Samoylov Island was continued and expanded.

Scientific investigations were focused on the following topics:

A. Permafrost soils and ecosystems (● Chapter 3: *Microbiological processes, trace gas fluxes and hydrobiology in permafrost ecosystems of the Lena Delta)*

B. Periglacial landscape dynamics (● *Chapter 4: Studies of periglacial landscape dynamics and surface characteristics studies in the western Lena Delta)*

C. Ground ice as climate archive (● *Chapter 5: Holocene ice wedges of the 1st Lena terrace)*

D. Modern delta hydrology (● *Chapter 6: Report of the hydrological work in the Lena River Delta in August 2005)*

Acknowledgements

The success of the expedition LENA 2005 would not have been possible without the support by several Russian, Yakutian, and German institutions and authorities. In particular, we would like to express our appreciation to the Tiksi Hydrobase and the Lena Delta Reserve, special thanks to D. Melnichenko and A. Gukov. The members of the expedition wish to thank the captains and crewmembers of the vessel “Neptun” and the staff of the Lena Delta Reserve station on Samoylov Island.

The LENA 2005 expedition was a contribution to the joint research project “Process studies of permafrost dynamics in the Laptev Sea” (project number 03G0589) founded by he German federal ministry of Education and Research (BMBF) as well as to the Russian German Science cooperation “SYSTEM LAPTEV SEA”:

2. Expedition itinerary and general logistics

Lutz Schirrmeister and Mikhail N. Grigoriev

Four research teams (Table 2-1) were formed to conduct the planned scientific tasks.

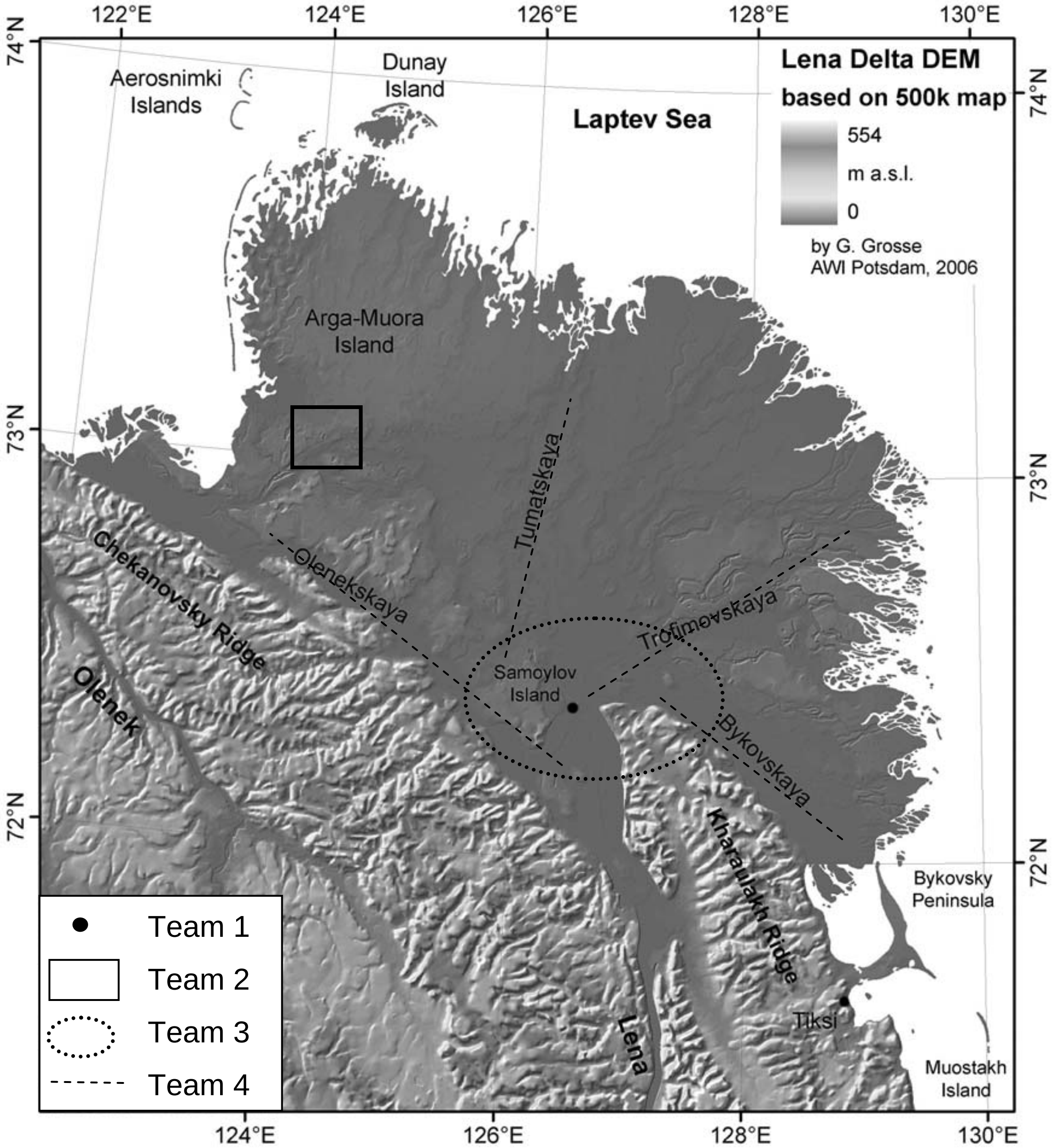

Figure 2-1: Study sites and itineraries during the expedition Lena-2005.

Team 1 was based at the biological station of the Lena Delta Reserve on Samoylov Island in the central Lena Delta from July 11 through September 5, 2005. This team was split into two groups of 8 and 10 persons and focused on:

- The characterisation of the structure and function of microbial communities taking part in the carbon budget in permafrost soils;
- The understanding of modern processes in permafrost soils (energy and water balance, methane fluxes);

- Studies of plankton formation in lakes of the central Lena Delta.

- ***Chapter 3: Trace gas fluxes and ecological studies in permafrost environments of the Central Lena Delta***

Team 2 consisted of 9 persons and was based at a field camp on Ebe Basyn Sise Island at the Arynskaya River Channel in the western Lena Delta from August, 14 to September, 1. This group was transferred to the camp-site by the river vessel "Neptun" and back to Tiksi by helicopter. It worked on several surrounding islands (Turakh Sise, Ebe Basyn Sise, Khardang), which were reached with a Zodiac boat. Team 2 focused on:

- Geological relations of Quaternary sequences of the "Arga-Complex" and of Khardang Island;
- Surface characteristics of periglacial landforms
- Dynamics of thermokarst lakes on the 2nd Lena Delta terrace.

- ***Chapter 4: Periglacial landscape dynamics and surface characteristics studies in the western Lena Delta***

Team 3 worked on Samoylov Island and along the main channels of the Central Lena Delta (Bykovskaya, Trofimovskaya, Tumatskaya, Olenekskaya, Arynskaya). This small team of two persons was based on Samoylov Island and reached study sites using a motorboat and the vessel "Neptun". The main focus of this group was to provide a:

- Better understanding of the genesis of the 1st Lena Delta terrace with a special focus on Holocene ice wedges

- ***Chapter 5: Holocene ice wedges of the 1st Lena terrace***

Team 4 consisted of 4 people collecting hydrological data of water discharge and sediment transport of several major channels of the Lena Delta. These studies were carried out on board of the river vessel "Neptun" as well as by several motorboats trips. The main objective of this group was to undertake:

- Palaeo-geographical and hydrological studies in the central Lena Delta.

- ***Chapter 6: Hydrological and geomorphological studies of the modern Lena Delta***

The general logistics of the LENA 2006 Expedition were jointly organized by the Permafrost Institute (Yakutsk), the Arctic and Antarctic Research Institute (St. Petersburg) and the Research Unit Potsdam of the Alfred Wegener Institute. Logistic operations in Tiksi (rental of buses, trucks, vessels, helicopters etc.) were organized by the Tiksi Hydrobase.

The list of participants and the addresses of the institutions involved are presented in Table 2-1 and Table 2-2.

Table 2-1. List of participants.

Name	email	Institution	Team
Ekatarina Abramova	abramova-katya@mail.ru	LDR	1
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Christian Wille	cwille@awi-potsdam.de	AWI	1

Table 2-2. List of participating institutions.

AARI	Arctic and Antarctic Research Institute Bering St. 38, 199397 St. Petersburg, Russia
SpSU	Sankt Petersburg State University, Faculty of Geography and Geo-ecology, Dept. of Hydrology; 33, 10th Line (Island Vasil'evskiy) St. Petersburg, 199178, Russia
LDR	Lena Delta Reserve 28 Academician Fyodorov St., Tiksi 678400, Yakutia, Russia
MGU	Moscow State University, Faculty of Paleontology 119899 Moscow, Russia
PIY	Permafrost Institute, Russian Academy of Science 677018 Yakutsk, Yakutia, Russia
UL	University Leipzig; Institute for Geography, Johannisallee 19a, 04109 Leipzig, Germany
AWI	Alfred Wegener Institute, Research Unit Potsdam PO Box 60 0149, D-14401 Potsdam, Germany
IFB	Institute for Soil Science, Hamburg University Allende-Platz 2, D-20146 Hamburg, Germany

3 Microbiological processes, trace gas fluxes and hydrobiology in permafrost ecosystems of the Lena Delta

3.1 Introduction

Dirk Wagner, Susanne Liebner and Eva-Maria Pfeiffer

Northern wetlands such as the Lena Delta in north-east Siberia are significant natural sources of methane (Friborg *et al.* 2003; Smith *et al.* 2004; Corradi *et al.* 2005) and other climate relevant trace gases. As a consequence of the harsh winter climate, decomposition processes in northern wetlands are inhibited leading to an accumulation of organic matter. The organic matter is partly decomposed under water-saturated, anaerobic conditions during the short summer period. The terminal step in the anaerobic decomposition of organic matter is the microbial formation of methane (methanogenesis). Several studies estimated the methane source strength of northern wetlands, including tundra, to range from 17 to 42 Tg CH_4 yr^{-1} (Whalen and Reeburgh 1992, Cao *et al.* 1996, Joabsson and Christensen 2001, Wagner *et al.* 2003). This corresponds to about 25 % of the methane release from natural sources (Fung *et al.* 1991).

Global warming could thaw 25 % of the permafrost area by 2100 (Anisomov *et al.* 1999) exposing huge amounts of currently fixed organic carbon to aerobic as well as anaerobic decomposition processes. Also, higher temperatures are likely to reinforce methanogenesis and therefore increase the methane source strength of Arctic wetlands (Wuebbles & Hayhoe 2002). Additional methane would have a positive feedback on the atmospheric warming process because methane is both on a mass and a molecule level 23 times more effective as a greenhouse gas than CO_2 (IPCC 2001).

The biological oxidation of methane by methane oxidising (methanotrophic) bacteria, which belong to the α- (type II methanotrophs) and γ- (type I methanotrophs) *Proteobacteria*, is the major sink for methane in terrestrial habitats. Between 43 and 90% of the methane produced in the soil is oxidised before reaching the atmosphere (Le Mer & Roger 2001, Roslev & King 1996). Hence, it is crucial to investigate methanotrophic communities and their response to global change in particular in climatic sensitive regions like the Lena Delta.

The nitrogen turnover is strongly correlated with the carbon cycle but little is known about nitrogen fluxes in Arctic ecosystems and the responsible organisms. Nitrifying bacteria were detected in old deep permafrost sediments, where they can survive long periods of starvation and dryness (Soina et al. 1991, Bartosch et al. 2002). Nearly nothing is known about the Arctic source strength for the long-life greenhouse gases NO and N_2O. Furthermore, the interaction of climate relevant processes like microbial CH_4 oxidation is influenced by the activity of ammonia oxidizers. The Artic carbon fluxes and turnover times are limited by the microbially mediated nitrogen mineralization.

Based on the experience and results of almost one decade of successful research in the Lena Delta region, the main focus of the eighth expedition was on trace gas flux measurements (CH_4, CO_2), to gain more insights into the relationships of structure and function of microbial communities involved in carbon decomposition and on the dynamic of zooplankton in the thermokarst lakes.

3.2 Dynamic of methane oxidising communities in permafrost soils

Susanne Liebner and Dirk Wagner

3.2.1 Introduction

Methane oxidation by obligately aerobic methane oxidising (methanotrophic) bacteria is the main sink for the greenhouse gas methane in terrestrial habitats. Our study investigates how the warming of the Russian tundra could alter methane fluxes by altering the methanotrophic community. In particular, we aim at investigating adaptation, phylogeny and dynamic of the methane oxidising community in ‘active layer’ samples from Samoylov Island.

3.2.2 Sampling procedure and field parameters

For the purpose of an investigation of the temporal and spatial dynamic of the methanotrophic community, active layer cores of a polygon rim, transition and a polygon center were sampled frequently at intervals of 3-4 days between July, 15th and September 1st 2005 (Figure 3-1). Active layer cores are listed in Table 3-1.

The sampling of the active layer cores was accompanied by measuring depth of the permafrost table, water level, water content and soil temperature. All parameters are summarized in Table 3-2. In addition, the pore water methane concentration of polygon rim, transition, and polygon center was determined (chapter 3.2.3). Beside the active layer cores, fresh soil samples of polygon rim and transition were taken for the determination of soil physical and chemical properties (Table 3-3).

Figure 3-1: Sampling of active layer cores within a low-centred polygon (N 72°22, E 126°28): Steel cores (l=50 cm, Ø=50 mm) were turned into the 'active layer', undisturbed cores were sampled, stored in plastic foil and frozen immediately after sampling for molecular processing in the lab.

3.2.3 Pore water methane concentration

Measurements of porewater methane concentration were carried out by placing fresh soil samples together with a saturated NaCl solution into glass jars. After intensive shaking of the closed jars, methane was forced from the soil solution into the headspace of the bottles and was analysed by gas chromatography. Methane concentrations are shown in Figure 3-2.

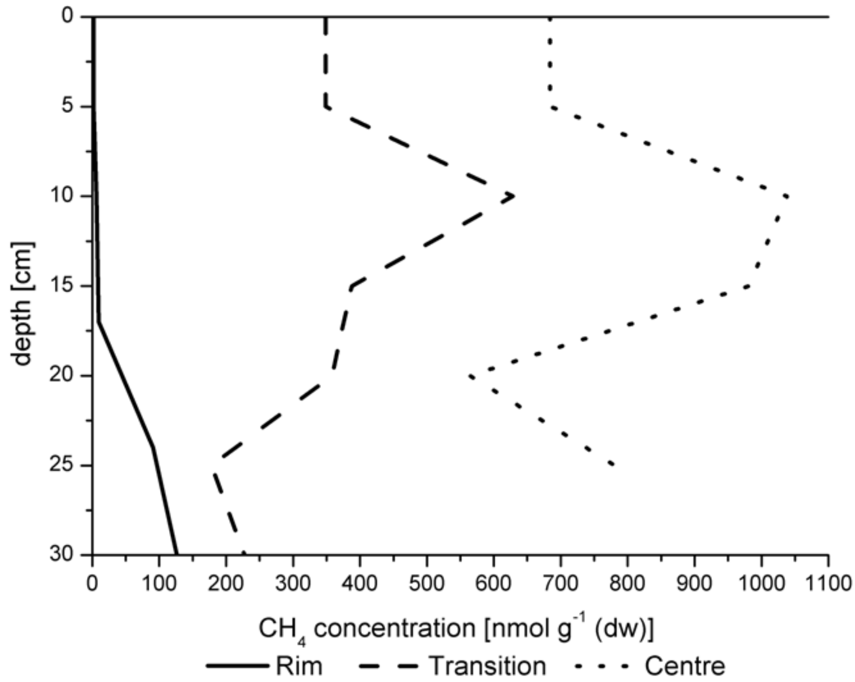


Figure 3-2: Methane concentration within a low-centred polygon (N 72°22, E 126°28). Date of measurement: 04.08.2005.

Table 3-1: List of active layer cores (length: 50 cm, Ø 50 mm, Box: 0285) of a low-centred polygon on Samoylov Island (N 72°22.2’, E 126°28.5’), sampling period: July 15th to September 1st 2005.

Core ID	Core No	Description	Date
LD05	AC_1	Rim	15.07.2005
LD05	AC_2	Rim	15.07.2005
LD05	AC_3	Rim	15.07.2005
LD05	AC_4	Transition	15.07.2005
LD05	AC_5	Transition	15.07.2005
LD05	AC_6	Centre	15.07.2005
LD05	AC_7	Centre	15.07.2005
LD05	AC_8	Rim	18.07.2005
LD05	AC_9	Transition	18.07.2005
LD05	AC_10	Centre	18.07.2005
LD05	AC_11	Rim	21.07.2005
LD05	AC_12	Transition	21.07.2005
LD05	AC_13	Centre	21.07.2005
LD05	AC_14	Rim	25.07.2005
LD05	AC_15	Transition	25.07.2005
LD05	AC_16	Centre	25.07.2005
LD05	AC_17	Rim	28.07.2005
LD05	AC_18	Transition	28.07.2005
LD05	AC_19	Centre	28.07.2005
LD05	AC_20	Rim	01.08.2005
LD05	AC_21	Rim	01.08.2005
LD05	AC_22	Transition	01.08.2005

Table 3-1: continued: List of active layer cores (length: 50 cm, Ø 50 mm, Box: 0285) of a low-centred polygon on Samoylov Island (N 72°22, E 126°28), sampling period: July 15th to September 1st 2005.

Core ID	Core No	Description	Date
LD05	AC_23	Centre	01.08.2005
LD05	AC_24	Rim	04.08.2005
LD05	AC_25	Transition	04.08.2005
LD05	AC_26	Centre	04.08.2005
LD05	AC_27	Rim	11.08.2005
LD05	AC_28	Transition	11.08.2005
LD059	AC_29	Centre	11.08.2005
LD05	AC_30	Rim	18.08.2005
LD05	AC_31	Transition	18.08.2005
LD05	AC_32	Centre	18.08.2005
LD05	AC_33	Rim	25.08.2005
LD05	AC_34	Transition	25.08.2005
LD05	AC_35	Centre	25.08.2005
LD05	AC_36	Rim	01.09.2005
LD05	AC_37	Transition	01.09.2005
LD05	AC_38	Centre	01.09.2005

Table 3-2: List of soil samples (Nalgene boxes) of a low-centred polygon on Samoylov Island (N 72°22, E 126°28), date of sampling: July 07th 2005.

Sample ID	Sample No	Description of soil horizons	Depth [cm]	Amount [ml]	Date
LD05	7190	A/O (rim)	0-6	750	18.07.05
LD05	7191	Bg (rim)	6-13	750	18.07.05
LD05	7192	Bg/Go (rim)	13-20	750	18.07.05
LD05	7193	Bg (rim)	20-27	750	18.07.05
LD05	7194	Bg/P (rim)	27-35	750	18.07.05
LD05	7195	A/O (transistion)	0-9	750	18.07.05
LD05	7196	Bg (transition)	9-15	750	18.07.05
LD05	7197	Bg (transition)	15-21	750	18.07.05
LD05	7198	Bg/P (transition)	21-25	750	18.07.05

Table 3-3: Field parameters of a low-centred polygon on Samoylov Island (N 72°22, E 126°28).

Date	Active layer depth [cm]			Water level* [cm]		Water content* [%]		Soil temperature [°C]			Depth [cm]
	rim	trans	centre	rim	trans	rim	trans	rim	trans	centre	
								4.5	8.3	9.4	5
								3.5	6.5	6.9	10
								2.7	4	5.8	15
15.7.05	32.7	29.7	30.7	17	2	n.d.		1.8	2.8	3.9	20
								0.8	1.5	2.4	25
									0.5	0.5	30
											35

Table 3-3 continued: Field parameters of a low-centred polygon on Samoylov Island (N 72°22, E 126°28).

Date	Active layer depth [cm]			Water level* [cm]		Water content* [%]		Soil temperature [°C]			Depth [cm]
	rim	trans	centre	rim	trans	rim	trans	rim	trans	centre	
								8.9	11.3	14.8	5
								7.2	8.9	10.2	10
								5.4	5.7	7.7	15
18.07.05	33.7	31.3	32	17	4	n.d.		4.2	3.8	5.6	20
								2.7	2.	3.5	25
								1.3	0.4	1.9	30
								0.2		0.5	35
								8.1	8.8	12.7	5
								7.5	8.2	10.4	10
								6.3	6.8	6.3	15
21.07.05	35.7	34	33	16	4	n.d.		5.3	5.4	3.8	20
								3.5	3.9	1.3	25
								2.2	1.9		30
								0.7	0.4		35
						52.6	31.1	5.3	6.1	8.2	5
						63.5	86.1	4.9	5.5	7.8	10
						68.1	87.6	4.3	4.4	6.9	15
25.07.05	37.3	33	34	17	4	100	100	3.5	3.4	5	20
								2.7	2.1	3.5	25
								2	1	2.1	30
								1.1		1.1	35

Table 3-3 continued: Field parameters of a low-centred polygon on Samoylov Island (N 72°22, E 126°28).

Date	Active layer depth [cm]			Water level* [cm]		Water content* [%]		Soil temperature [°C]			Depth [cm]
	rim	trans	centre	rim	trans	rim	trans	rim	trans	centre	
						56.3	32	4	5.5	6.7	5
						67.8	87.6	3.7	5.	6.2	10
						73.1	87.6	3.3	3.7	5	15
28.07.05	38.7	35	35	18	6	100	100	2.7	3	3.9	20
								2.1	2.1	2.9	25
								1.7	1.2	1.9	30
								1.3	0.4	0.9	35
						65.2	36.9	6.3	6.5	0.4	5
						71.5	87.6	5.7	6.3	8.4	10
						77.6	87.6	5.3	5.3	7.8	15
01.08.05	40.3	37	37	16	4	100	100	4.7	4.4	6.7	20
								3.4	3.2	5.3	25
								2.6	1.9	3.6	30
								1.8	1	2.7	35
						81.7	48.9	5.4	6	7	5
						87.6	100	4.8	5.2	6.1	10
						100	100	4.3	4.1	5.1	15
04.08.05	41.7	36.7	37	16	4	100	100	3.6	3.2	3.7	20
								2.7	2.3	2.8	25
								2.1	1.5	1.8	30
								1.6	0.7	0.9	35

Table 3-3 continued: Field parameters of a low-centred polygon on Samoylov Island (N 72°22, E 126°28).

								5.2	7.1	11.8	5
								4.4	5.1	11.7	10
								3.6	3.5	8.9	15
18.08.05	45.7	36	45.5	13.5	2	n.d.		3	2.9	7.1	20
								2.5	2.3	5.6	25
								2	1.6	5.1	30
								1.6	0.9	3.9	35
						n.d.	n.d.	3.3	4.6	4.2	5
						60.2	46.8	2.8	3.6	3.6	10
						75.7	87.6	2.6	2.7	3	15
25.08.05	47.3	39	37.3	13	1	81.3	100	2.2	2	2.4	20
								1.9	1.7	1.9	25
								1.7	1.3	0.9	30
								1.4	0.8		35
						n.d.	n.d.	2.3	2.3	3.4	5
						58.9	57.1	2.2	2.1	2.7	10
						72.3	100	2.1	2	2	15
01.09.05	48	40.7	36.3	10	0	74.1	100	1.9	1.9	1.5	20
								1.8	1.8	1	25
								1.5	1.3	0.6	30
								1.3	0.9	0.2	35

* water-level above surface of the polygon centre, n.d.=not detected, trans=transition

3.2.4 Sample processing and analyses

Active layer cores that were frequently sampled from a low-centred polygon will be further investigated on the basis of a molecular approach. Using the microbiological lab-facilities at the Alfred Wegener Institute in Potsdam, DNA as well as mRNA will be extracted from different depths of a polygon rim, a polygon centre and the transition zone. Polymerase chain reactions (PCR) will be carried out to amplify ribosomal and functional genes. These genes will be analysed in terms of phylogenetic relatedness, species diversity and the spatial and temporal dynamics within the arctic summer period. For this purpose, 16S rDNA clone libraries shall be designed supplemented by *in-situ* cell counting using fluorescence hybridization. Furthermore, molecular fingerprinting will be done using the denaturing gradient gel electrophoresis (DGGE). This will lead to a comprehensive understanding of the dynamic and diversity of the methanotrophic community within low-centred polygons on Samoylov Island.

3.3 Microbial studies on nitrification from permafrost environments

Claudia Fiencke, Susanne Kopelke and Eva-Maria Pfeiffer

3.3.1 Introduction

Since artic wetland soils are the most important natural source of the climate relevant trace gas methane, many investigations focused on the microbial C-cycle of permafrost soils. But despite a close connection between C-cycle and N-cycle, the N-cycle is mostly unexplored.

Nitrogen as carbon cycling in arctic ecosystems is dominated by physical and biogeochemical controls which are unique to the generally cold-dominated environment. Drastic seasonal fluctuations in temperature, a short growing season, cold soil temperature and the occurrence of permafrost are some of the obvious physical controls on nitrogen cycling and biological activity. Most of the nitrogen accumulates in the organic substance in response to low soil temperatures, excessive soil moisture and low soil oxygen concentration (Gersper et al., 1980, Marion & Black, 1987; Nadelhoffer et al., 1991, Schimel et al., 1996). Standing crop in tundra vegetation store about 2 times more nitrogen than temperate grasslands (Van Cleve & Alexander, 1981). But through the low N-mineralisation rates and lack of N-input by N-fixation and N-pollution the soils are nitrogen deficient and rely to a large extent on internally recycling (McCown, 1978).

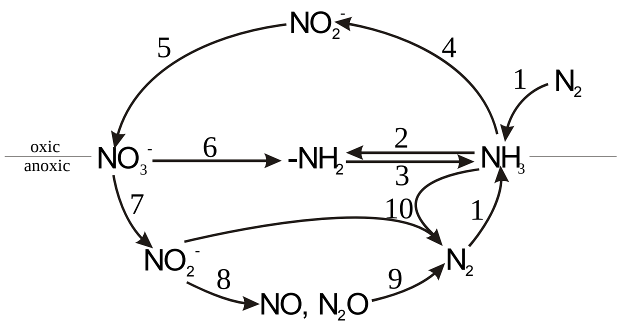


Figure 3-3: Nitrogen cycle. (1) Dinitrogen (N_2) fixation, (2) assimilation of ammonia (NH_3) to amino group ($-NH_2$) of protein, (3) ammonification, (4) ammonia oxidation, (5) nitrite (NO_2^-) oxidation, (6) assimilation of nitrate (NO_3^-), (7, 8, 9) denitrification via nitrite, nitric oxide (NO) and nitrous oxide (N_2O), (10) anaerobic ammonia oxidation.

N-cycling in the soil is crucial for growth of plants and microorganisms. Unbalances in N-cycling due nitrate leaching, nitrogen oxide release and increase the methane emission (Adamsen & King, 1993; Carini et al., 2003). Most of the N-transformations were catalyzed by microorganisms (Figure 3-3, Fiencke et al., 2005).

Nitrification, the microbiological oxidation of ammonia to nitrate via nitrite, occupies a central position within the terrestrial nitrogen cycle (Figure 3-3: step 4 and 5). Aerobic chemolithoautotrophic ammonia and nitrite oxidizing proteobacteria represent the most important group of nitrifying bacteria (Fiencke et al., 2005). As a result of nitrate and acid formation, the nitrification process has various direct and indirect implications of soil systems. It increases the loss of soil nitrogen due to leaching of nitrate and volatilization of nitrogen gases directly or by denitrification and therefore, influences the nitrogen supply to plants.

Nitrifying bacteria are found in the upper layer of soils like rhizosphere where organic matter is mineralized, and ammonia and oxygen are present. The slow growth rates and difficulties in recovering pure cultures have hampered cultivation-dependent approaches to investigate the number, community composition and dynamics of nitrifiers in soil. The number and turnover rate is therefore determined by traditionally methods like most-probable-number (MPN) technique and activity tests.

During the Expedition to the Lena Delta in summer 2005 microbial nitrification were investigated by field experiments. Furthermore soil and gas samples were taken for further ecological, molecular and soil analyses.

3.3.2 Field experiments: Impact of polygonal soil parameter on nitrification

Methods: Quantification of nitrifying bacteria and activity measurements

The investigations of nitrification were carried out on Samoylov in August 2005. Soil samples were taken from two polygons, at the polygon rim and polygon center, at 3 depths (0-5, 5-15, 15-25 cm). From the fresh samples nitrifying bacteria, ammonia and nitrite oxidizing, were enriched for further quantification by MPN-technique in media with 1 mM ammonium and 0.3 mM nitrite at about 6°C. In the same samples the ammonia oxidizing activities were measured at about 17°C. To determine the influence of time and temperature the cell numbers and activities of nitrifiers in the same samples will be later analyzed after transportation above and below 0°C in our institute in Hamburg. For the first impression of N_2O emission of the soils, gas samples were taken at the same sites. The ammonia oxidizing community will be further characterized by sequencing of *amoA*.

Preliminary results

Although the data were not completely analyzed, first results show obvious similarities to the samples taken last year (July 2004). The chemical characterization of the soil samples shows that in the moist, anaerobic and methane containing polygon center ammonium accumulates and only low concentration of nitrite and nitrate were found (Figure 3-4a). In the dryer polygon rim high nitrate concentration were found in the oxic top soil (Figure 3-4b).

In the dryer, aerobic polygon rim high nitrate and low inhibitory methane concentrations correlated with high cell numbers and activities of ammonia oxidizing bacteria (Figure 3-5a). In contrast in the moist, anaerobic, methane containing polygon center lower cell numbers and activities of ammonia oxidizing bacteria were detected (Figure 3-5b).

The results show that small scale differences in soil hydrology have significant impact on the N-cycle. Better drained, reduced acidity and methane concentration of oxic soil samples of the polygon rim favour nitrification and therefore leads to the accumulation of nitate. Nitrate was possibly not degraded in dry sites owing to lack of denitrification in these more aerated micro-environments. Instead in the moist polygon center nitrification was inhibited by oxygen deficiency and therefore the ammonium formed by mineralization was accumulated. In the moist anoxic environment nitrate were possibly fast reduced by denitrification.

Further investigations will consider unstudied processes and fluxes in the N-cycle like mineralization and dentrification.

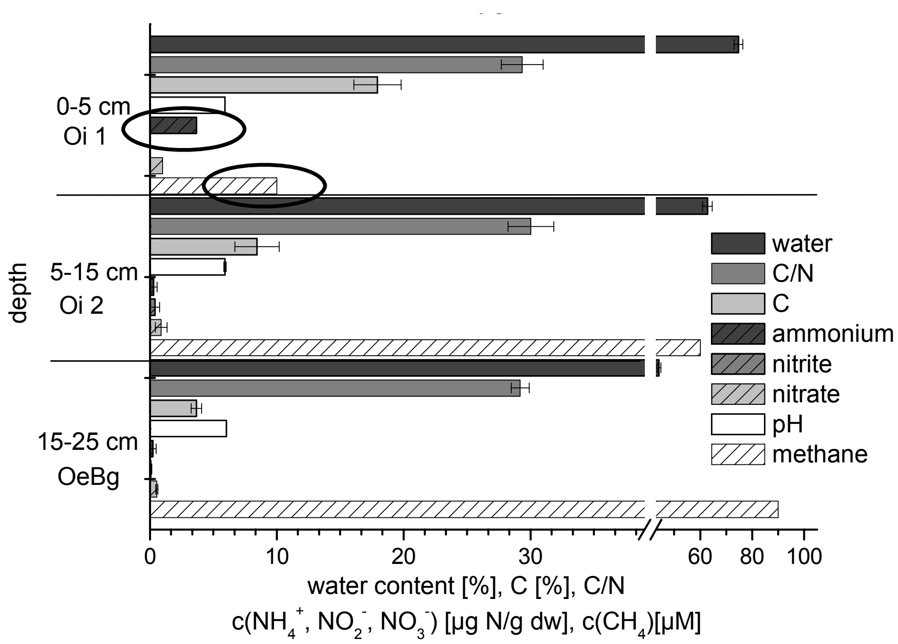


Figure 3-4b: Chemical soil parameters of polygon center.

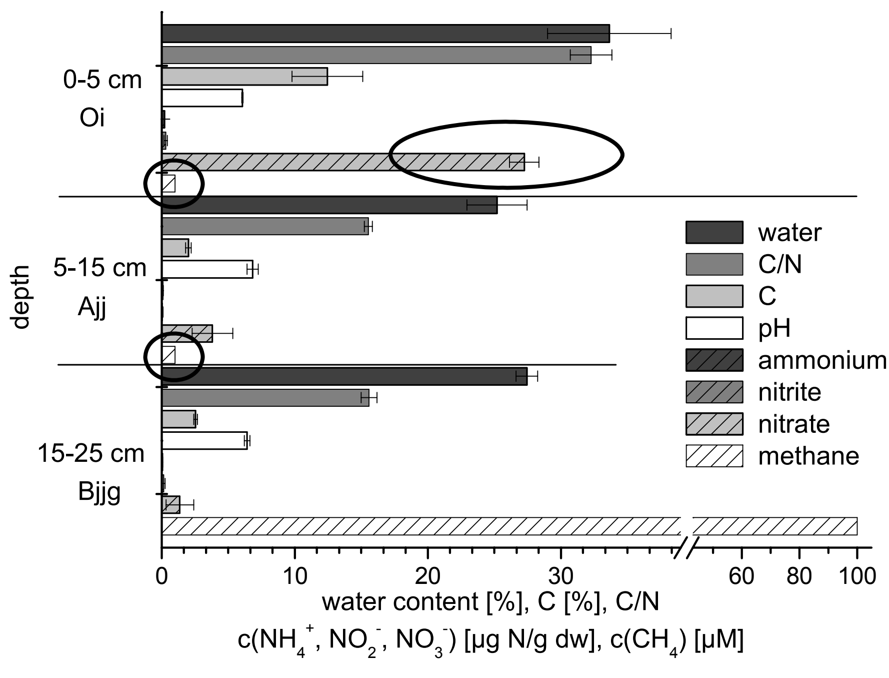


Figure 3-4a: Chemical soil parameters of polygon rim.

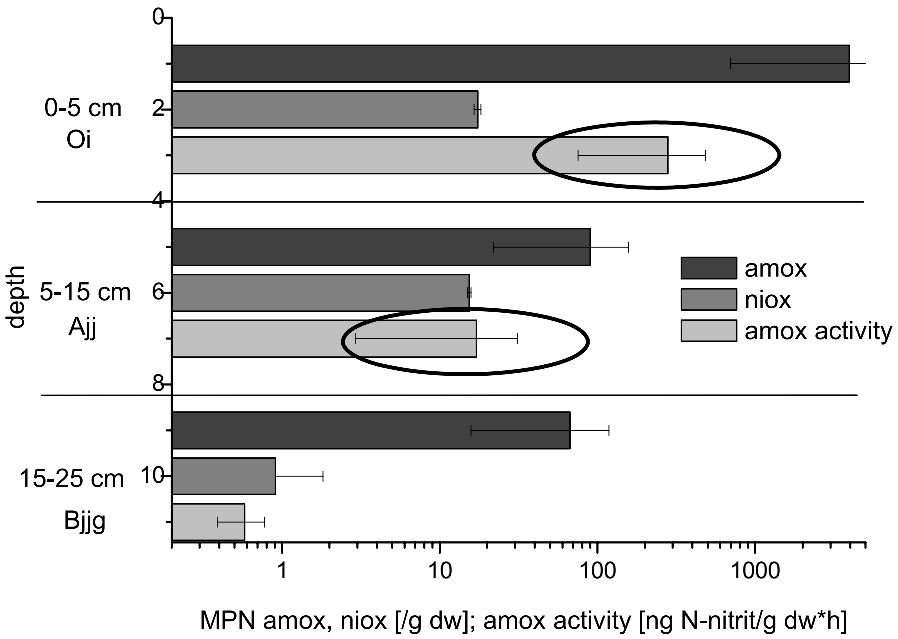


Figure 3-5a: Cell numbers of ammonia oxidizers (amox), nitrite oxidizers (niox) and ammonia oxidizing activities of soil samples of the polygon rim. Cell numbers were determined by MPN-technique after incubation for 9 weeks at 6°C. Activities were measured at 17°C and 0.75 mM ammonium.

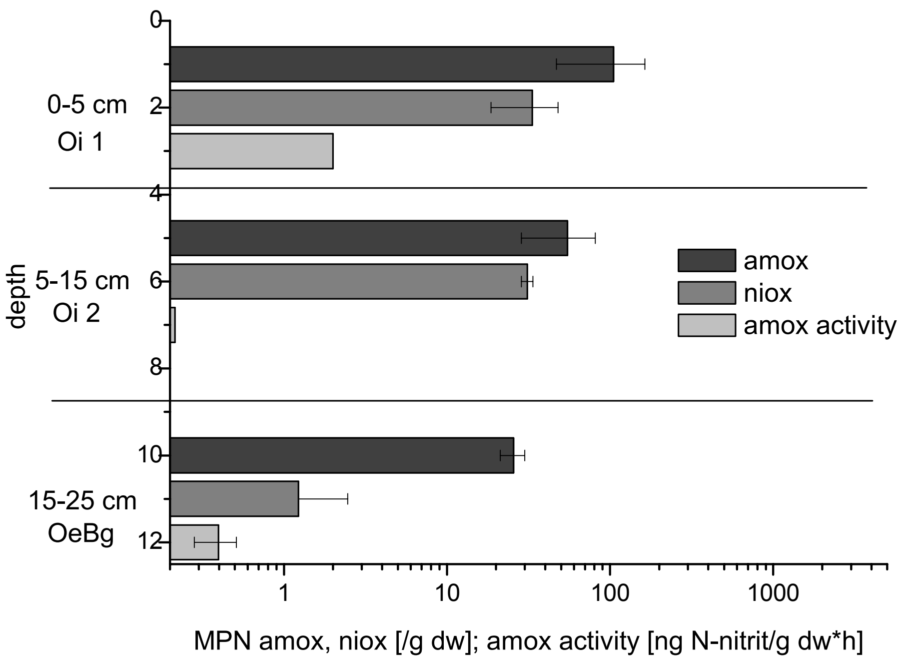


Figure 3-5b: Cell numbers of ammonia oxidizers (amox), nitrite oxidizers (niox) and ammonia oxidizing activities of soil samples of the polygon center. Cell numbers were determined by MPN-technique after incubation for 9 weeks at 6°C. Activities were measured at 17°C and 0.75 mM ammonium.

3.4 Closed chamber measurements of carbon exchange between Arctic tundra and the atmosphere

Torsten Sachs and Dirk Wagner

In addition of the long-term studies on methane emission carried out since 1998 (e.g. Wagner and Bolshiyanov, 2006), in 2005, an additional measurement field for closed chamber flux measurements was installed in close proximity to the eddy covariance tower. Altogether, 18 chambers were set up in four polygons and one polygon wall site (Figure 3-6). The four polygons are in different stages of development and feature different vegetation, with one polygon being a high-center polygon.

Figure 3-6: Air photograph of the measurement field for closed chamber flux studies in close proximity to the eddy covariance tower (on the left side in the photo background)

The purpose of these additional chamber measurements within the eddy covariance footprint is:

- to determine the small scale variability of carbon dioxide and methane fluxes and its influence on the quality of eddy covariance data
- to improve process understanding of the underlying single processes that make up parameters measured by eddy covariance
- to help develop robust models and scaling algorithms for up-scaling flux data from plot to landscape scale and beyond

The chambers consist of a 50x50 cm PVC base inserted about 10 cm into the active layer. A water-filled channel on top of the base provides a gastight seal between the base and the actual chamber. Four ports on top of the PVC chambers are used to draw sample air as well as to circulate the air inside the chamber with an external pump. Chamber volume is 12.5 liters and 25 liters where higher vegetation does not allow for the use of small chambers. Dark PVC chambers are used for measurements of respiration and transparent chambers are used for measurements of net carbon dioxide flux and methane flux. Measurements were conducted from August 7 through August 31, 2005 using an Innova AirTech Instruments Multi-gas Monitor Type 1302. For carbon dioxide fluxes, samples were drawn from the chamber headspace every minute for 5 minutes, and for methane fluxes samples were drawn every minute for 8-10 minutes. Samples were analyzed by photo-acoustic infrared spectroscopy and flux rates will be calculated from the change of concentration during closure time. Preliminary viewing of the data indicates some variability of fluxes within the micro-sites and clear variability between the different polygons. The high-center polygon shows fluxes more similar to those of the polygon wall than to those of other polygons. The clear decrease of photosynthesis visible in the eddy covariance data series can also be seen in chamber measurements of net carbon dioxide. Methane data show the most significant difference between polygon centers and the polygon wall with concentrations at the polygon wall micro-site reaching the instrument’s detection limit and very high concentrations at polygon center micro-sites.

3.5 Micrometeorological measurements of energy, water, and carbon exchange between Arctic tundra and the atmosphere

Torsten Sachs, Christian Wille, Günter Stoof and Dirk Wagner

The micrometeorological measurements of the years 2002 – 2004 were continued during the 2005 campaign. They comprised the determination of the turbulent fluxes of energy, water vapor, carbon dioxide and methane from the ground into the atmosphere using the eddy covariance technique, as well as the measurement of supporting meteorological and soil-physical parameters. The measurements lasted from July 17 through September 1. The investigation site and the technical set-up of the eddy covariance system (ECS) and supporting measurements were identical to 2003. For a detailed description see Kutzbach et al. (2004a).

The meteorological conditions on Samoylov Island during the study period 2005 are given in Figure 3-7a-c. The air temperature and net radiation show the usual diurnal pattern and also illustrate the seasonal progression from summer to autumn. The turbulent fluxes of sensible and latent heat, carbon dioxide and methane are presented in Figure 3-7d-g. The data series show clear diurnal and seasonal trends, except for methane. The sensible heat flux reached maximum daytime values of up to +200 W m^{-2} and nighttime minimum fluxes of down to -50 W m^{-2} until the end of July. After this, the sensible heat flux decreased to reach maximum daytime values of about +110 W m^{-2}; negative nighttime fluxes remained in the range of fluxes in July. Similarly, the latent heat flux showed maximum values of up to +200 W m^{-2} in the first week of the campaign and remained mostly above 100 W m^{-2} until the end of July. In August latent heat fluxes were typically below 100 W m^{-2}. CO_2 flux showed a clear diurnal pattern during the entire measurement campaign. Up until August 12, daytime CO_2 uptake typically reached or exceeded 100 µg s^{-1} m^{-2}, while nighttime CO_2 emissions never exceeded 50 µg s^{-1} m^{-2}. After August 12, photosynthetic activity began decreasing, resulting in daytime fluxes of typically only around -50 µg s^{-1} m^{-2}. Methane flux measurements could also be conduced successfully. Methane fluxes showed no diurnal or seasonal trends. A strong peak with a maximum flux of more than 1.9 µg s^{-1} m^{-2} was detected on July 31 and corresponds to a peak in methane fluxes measured by closed chambers. Typically, methane fluxes remained below 0.4 µg s^{-1} m^{-2} and only exceeded 0.9 µg s^{-1} m^{-2} on three occasions during the entire measurement period.

Further work will go into the analysis and interpretation of this data.

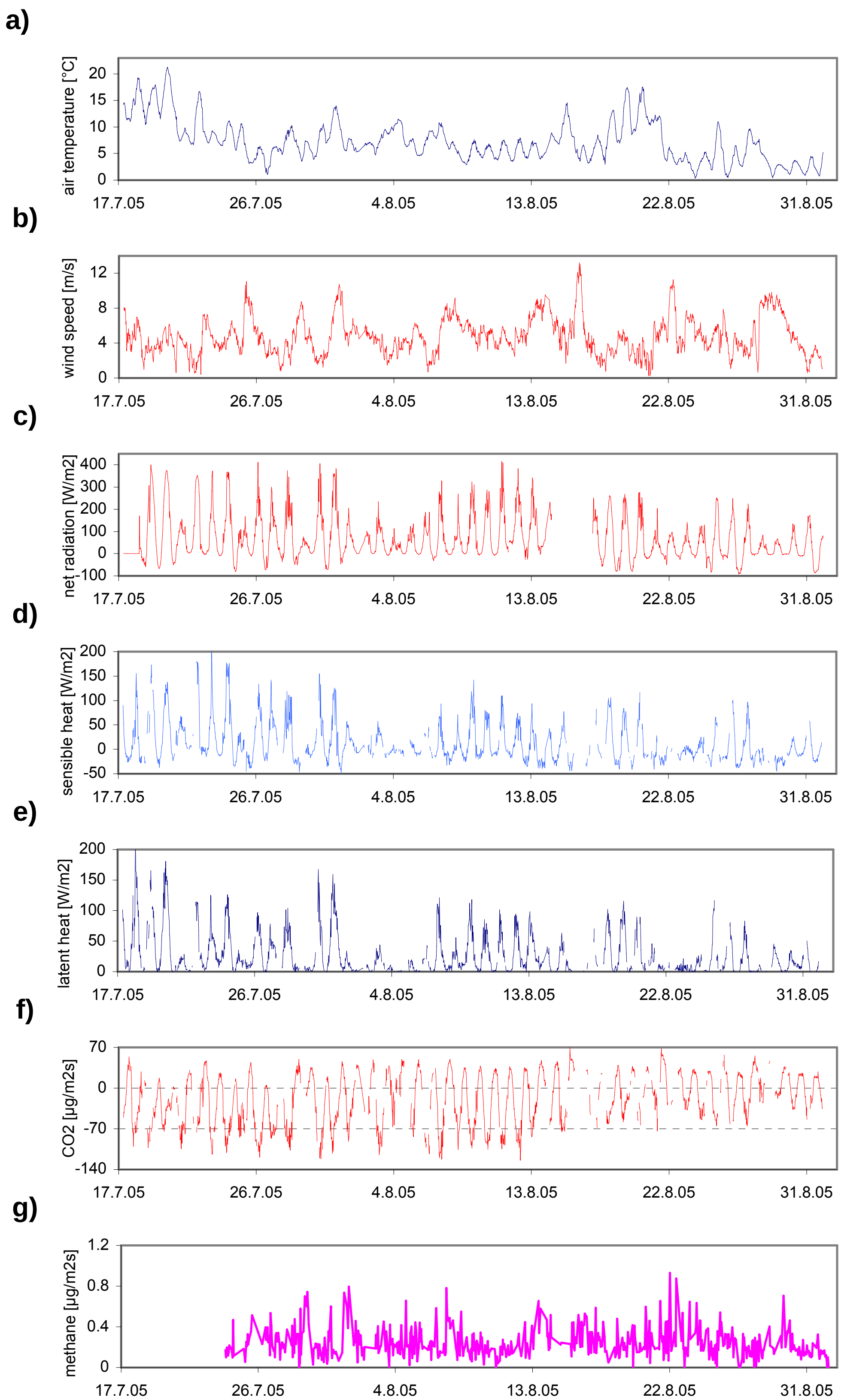


Figure 3-7: Data from the eddy covariance system on Samoylov Island during the study period July 17 through September 1, 2005. – a) air temperature at 2 m height, b) wind speed, c) net radiation, d) sensible heat flux, e) latent heat flux, f) carbon dioxide flux, g) methane flux. All values are half hour averages.

3.6 Energy and water budget of permafrost soils – long time meteorology and soil survey station on Samoylov Island

Christian Wille und Julia Boike

The permanent meteorology and soil survey station on Samoylov Island is situated about 200 meters northeast of the Lena Delta reserve station building on a Holocene river terrace which is characterized by polygonal tundra with raised, dry polygon rims and low, wet polygon centers. The station was set up during the Lena 2002 expedition and put into operation on 24.08.2002. For detailed information about the setup of the measurement station see Wille et al., (2003).

The data recorded by the measurement station and the sensors used are given in Table 3-4. Meteorological data (Pos. 1-5 in Table 3-4) was sampled every 20 seconds and hourly averages were stored. Soil temperature and heat flux was measured every 10 minutes and hourly averages were stored while snow height, electrical conductivity and volumetric water content were sampled and stored every hour.

During the Expedition Lena 2005 no changes were made to the measurement station. The meteorological sensors, the rain gauge and the snow height sensor were cleaned and checked for proper operation. The station had worked continuously since July 2004 and has thus collected continuous data since July 13, 2003. The raw data will be transferred to an SQL database which is hosted by the Institute of Environmental Physics at the University of Heidelberg and subsequently analyzed.

Table 3-4: Data and sensors of permanent measurement station

Pos.	Data Measured	Sensor Type
1	Air Temperature and Air Relative Humidity (0.5 and 2.0 m above ground)	Rotronic Meßgeräte GmbH Meteorological Probe MP103A
2	Wind Speed & Wind Direction (3.0 m above ground)	R M Young Company Anemometer 05103
3	Net Radiation (1.35 m above ground)	Kipp & Zonen B.V. Net Radiometer NR-Lite
4	Outgoing IR-Radiation (1.28 m above ground)	Kipp & Zonen B.V. Pyrgeometer CG1
5	Precipitation (liquid, i.e. Rain) (0.3 m above ground)	R M Young Company Tipping Bucket Rain Gauge 52203
6	Snow Height (in centre of polygon)	Campbell Scientific Ltd. Sonic Ranging Sensor SR 50
7	Soil Temperature (4 measuring profiles)	Campbell Scientific Ltd. Thermistor Soil Temperature Probe 107
8	Soil Bulk Electrical Conductivity (3 measurement profiles)	Campbell Scientific Ltd. TDR 100, Probe CS605
9	Soil Volumetric Water Content (3 measurement profiles)	Campbell Scientific Ltd. TDR 100, Probe CS605
10	Heat Flux out of / into Soil (2 measurement points)	Hukseflux Thermal Sensors Heat Flux Sensor HFP01

3.7 Isotopic Studies on the ^{13}C-fractionation during CH_4-production in Polygonal and Thermokarst Lakes of the Lena Delta

Eva-Maria Pfeiffer, Christian Knoblauch, Günter Stoof, Dirk Wagner and Hanno Meyer

3.7.1 Introduction and methods

Besides the wet tundra soils small polygon ponds of ice wedge patterned ground and thermokarst lakes are important methane sources in permafrost affected landscapes (Semiletov et al. 1996, Makov & Bazhin 1999, Huttunen 2001, Spott et al. 2003, Spott 2003). During the last years many investigations focused on the microbial C-cycle of permafrost soils (e.g. Pfeiffer et al 2002, Wagner et al. 2003, Kutzbach et al. 2004b, Kutzbach 2005, Liebner and Wagner, 2006). But despite a close connection between C-soil- and C-lake-cycle, the strength of the lakes source is still not well investigated. During the expedition Lena 2005 different lakes of the polygonal tundra and one thermokarst lake on the Islands Samoylov and Kurungnahk have been investigated and sampled by a special sediment core equipment for lake sediments (see Fig. 3-8). Correlating soil and sediment next to the lakes are sampled. Additional ice samples of typical ice wedge and ice bodies of different near Samoylov Island were sampled for the determination of the CH_4 concentration and ^{13}C signature. All samples have been degased in the field and the CH_4 concentrations have been determined with the field GC. The ^{13}C-values of methane were determined at the Institute of Soil Science of the University of Hamburg using an isotopic-ratio mass spectrometer (Delta plus, Finnigan MAT) with a preconcentration unit (Precon), and a gas chromatograph (Agilent 6890) connected to the MS via a GC/C interface.

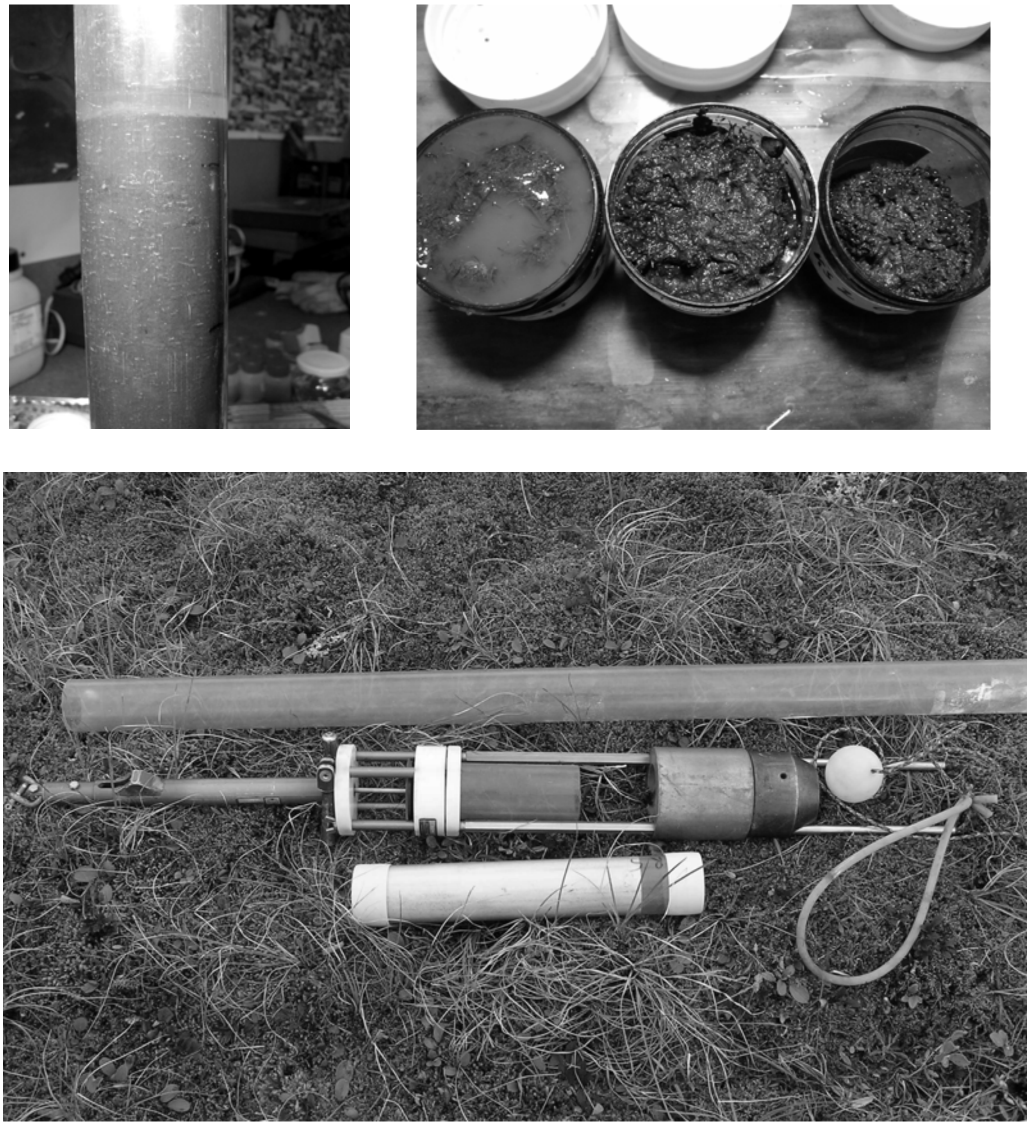


Figure 3-8: Sampling equipment and sediment samples (note oxic and anoxic zone in the core) of the thermokarst lake (Fish lake) on Samoylov Island, Lena Delta

3.7.2 Preliminary results and further plans

The methane concentrations of gas of the water column and sediment samples are shown in Fig. 3-9 and 3-10. The first results show a distinct isotopic fractionation of methane in the water column and of methane of sediments in different depth in the lake. The values range from -60 ‰ to max. -77 ‰ ^{13}C. Methane concentrations were low in the sediment surface but increase in the deeper, anoxic sediment layers. Highest concentrations of 79 % methane were measured in gas bubbles of the reduced sediment (Fig 3-9a). The ^{13}C-isotope signatures in the methane production zone showed very light values of -71 to

-77 ‰ (VPDB), as they are characteristic for archaeal methanogenesis. Methane at the surface showed lower concentrations and generally heavier ^{13}C-values being indicative for an active methane oxidation in the surface sediments.

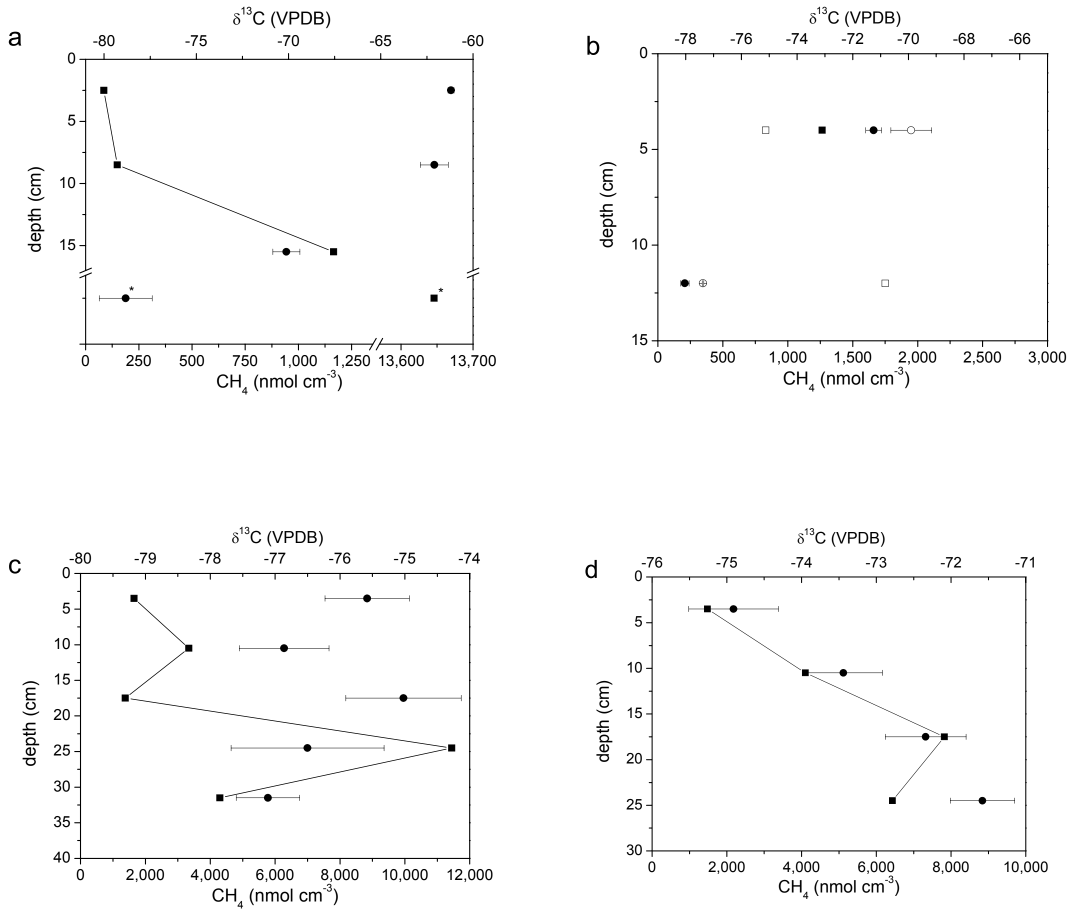


Figure 3-9: CH_4 concentrations (squares) and ^{13}C-values of CH_4 (circles) of two polygonal lakes on Samoylov island (panel a and b Olly lake, sampling 1 m (panel a), 2 m (panel b closed symbols) and 5 m (panel b open symbols) from the shore line. Asterix in panel a marks values from gas bubbles from the anoxic sediment layer. Panel c and d KS-lake from Kurungnahk Island (c: KS 50 in 50 m and d: KS 100 in 100 m from the shore line) in the Lena Delta, August 2005.

The ^{13}C analysis have to be finished and interpreted in context of biogenic and geogenic methane formation. All so far determined values indicate the biogenic methane formation of CH_4 in the different lake compartments. Further investigations are necessary.

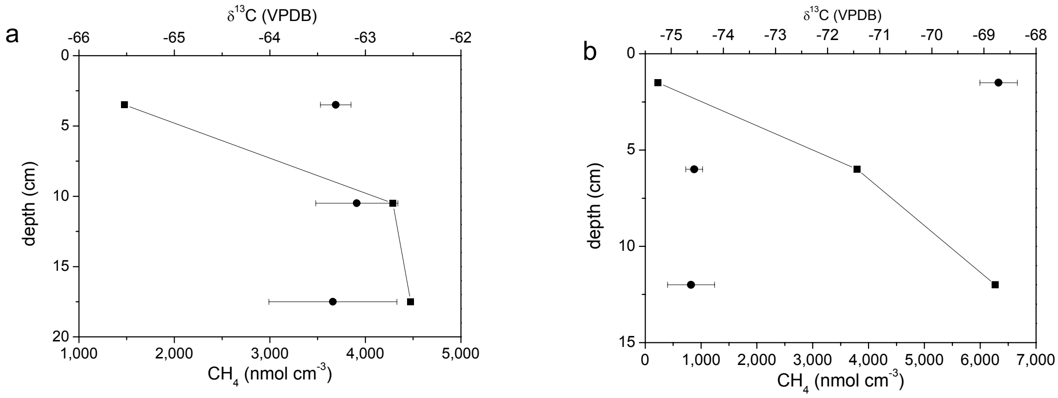


Figure 3-10: CH_4 concentrations (squares) and ^{13}C-values of CH_4 (circles) in the water column (panel a) and sediment (panel b) of a thermokarst lake (Fish lake) on Samoylov Island, August 2005

3.8 Hydrobiological investigations in the Lena Delta

Ekatarina N. Abramova, Günter Stoof and Waldemar Schneider

3.8.1 Objectives

During last two decades of investigations we have got the detailed data about species composition and distribution of pelagic fauna in the different lakes of the Lena Delta. A total of 128 taxa of zooplankton were identified. The highest species diversity was found in the terrace lakes influenced by river waters in the period of spring runoff. Riverine waters bring nutrients, organic matter, phytoplankton, and zooplankton species into these lakes. The big thermokarst lakes of the second and third terrace are oligotrophic and isolated from river waters influence. Zooplankton of these lakes is poor qualitatively as well as quantitatively. Numerous polygonal ponds are the most productive ecosystems to compare with other types of the the lakes in the Lena Delta. The species composition is very similar in polygonal ponds situated in different parts of the delta. The homogeny in distribution of the pelagic fauna is seemingly related to wind-induced dispersion of inactive stages of the pelagic organisms after drying of polygonal ponds.

The seasonal dynamics of zooplankton species composition, abundance, biomass, and production has good pronounced in the different types of lakes conformities connected with environmental conditions and the live cycle of the common zooplankton species and depends on a certain year.

During the expedition "Lena-Delta-2005" the monitoring investigations of zooplankton on the Samoylov and Buor-Khaya Islands were continued.

3.8.2 Research tasks

To collect new data about biodiversity, ecology, population structure, and seasonal dynamics and production of zooplankton in the lakes on the Samoylov and Buor-Khaya Islands

To analyze the interannual variations in the zooplankton community inhabited of the different lakes ;

To estimate the influence of riverine water upon pelagic fauna formation in the different types of the lakes on the Samoylov Island

3.8.3 Material and methods

Sixty quantitative and twenty qualitative zooplankton samples were collected during the period of investigation (July – August 2005) on Samoylov Island: 17 samples – from flood-plain lakes, 10 – from deep polygon without plants, 10 – from shallow polygon with plants, 10 – from the crack between polygons, 23 -

from big thermokarst lakes situated in the different parts of the Island, 10 - from Olenekskya channel (Figure 1). Eight quantitative samples of zooplankton were collected from alases and polygons on Buor-Khaya Island.

Figure 3-11: Positions of zooplankton sampling on Samoylov Island: 1 - flood-plain lakes, 2 - polygons and ice crack, 3 - big thermokarst lakes, 4 - Olenekskaya channel

As in the previous years, sampling of zooplankton was performed by filtering of 50-100 litres of water through a 100-µm-mesh size net with periodicity of every 5-6 days and fixation with 70% alcohol or 4% borax-buffered formalin. In the big thermokarst lakes the vertical catches (from bottom to surface) were made with plankton net (0.05 m2 mouth opening, 100 µm mesh size).

Either the whole sample or part of it was analyzed in a Bogorov chamber under a binocular microscope "MBS-10". Detailed taxonomic composition and size of plankton organisms (with an accuracy of one hundredth of micron) were carried out using Olympus SZX9 and Olympus BX60 microscopes with the adjusted camera and computer program “Analysis” in the Otto Schmidt Laboratory in St.-Petersburg. To identify individual weights of organisms, we used the formula: W=qlb, where W is body weight, l – body length (mm), q – weight at 1 mm body length, b – index.

Characteristics of four taxonomic categories (Rotatoria, Anostraca, Copepoda and Cladocera) were studied in detail. Almost all adult organisms were determined to species level. Juvenile copepods were separated into copepodite stages and identified to species/genus level. Nauplii of Cyclopoidae and Calanoidae species (Copepoda) were counted separately, but without species identification. The abundance [ind./m3] was calculated for species, different age stages, principal taxa and total organisms in each sample.

Both total biomass, abundance, and species composition were associated with the temperature fluctuations of the water in the different water pools. Water temperature was measured simultaneously with plankton sampling.

3.8.4 Preliminary results

New data on species composition, distribution, productivity, and life cycles of plankton species were obtained as well as ecological aspects of their habitat use. As usually, a relatively low species diversity was discovered in the polygons with 27 zooplankton species on the Samoylov Island. Like in the last years, in July-August 2005, the taxonomic composition and abundance were dominated by the Heterocope borealis, several species of Diaptomidae family (Copepoda) and Daphnia pulex (Cladocera). The contribution of these species reach >80% of the total abundance and > 50% of the total biomass in the polygons lakes. A similar species composition and abundance of pelagic organisms was recorded in the polygons lakes on Buor-Khaya Island.

The highest species diversity and abundance were found in flood-plain lakes on Samoylov Island. Of all specimens collected from these lakes, about 90% belonged to Rotatoria and Copepoda species. Rotatoria (mainly *Keratella cochlearis, Asplanchna priodonta, Notholca acuminata, N. squamula, Polyarthra* spp. and *Euchlanis* spp.) and juvenile Cyclopoida and Harpacticoida constitute more than 80% of the total zooplankton abundance in July 2005. In August, the taxonomic composition and abundance were dominated by the same Rotatoria and Calanoida species belonged to Diaptomidae family and Eurytemora genus.

Different patterns of zooplankton composition in comparison with the privies years were observed in the flood-plain lakes on Samoylov Island in summer

2005 connected with the riverine water impact to these lakes during spring tide. Several new pelagic species for this region, such as *Eurycercus glacialis, Paracyclops fimbriatus, Macrocyclops albidus*, *Cyclops* sp. and others were found. Their share in the total zooplankton abundance in some flood-plain lakes on Samoylov Island was quite high, up to 30 % of the total number of organisms. According to our previous observations these species are common and abundant in the lakes on the Tit-Ary Island situated about 60 km to the south from Samoylov Island. It is possible, that we observe now the beginning of expansion of the boreal fauna representatives into the more northern regions is caused by the increasing influence of river run-off during last years. The trend in runoff observed in the Lena River basin increased by 10% from 1936 to 2001 due to the extended wet period during the second part of the last century (Berezovskaya et. al., 2005). An increased mean annual river discharge of 10-25% for the rivers that flow into the Arctic, with greater increases in winter and spring and a shift in the timing of peak flows to earlier in the spring is projected by models for the next 100 years (ACIA, 2004).

3.9 References

ACIA (2004) Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press.

Adamsen, A.P.S. und G.M. King (1993) Methane consumption in temperate and subarctic forest soils: rates. vertical zonation, and responses to water and nitrogen. Appl. Env. Microbiol. 59:485-490.

Anisomov, O.A., Nelson, F.E., and Pavlov, A.V. (1999) Predictive scenarios of permafrost development under conditions of global climate change in the XXI century. *Earth Cryology,* **3**, 15-25

Bartosch S., Hartwig C., Spieck E. and Bock, E. (2002). Immunological detection of Nitrospira-like bacteria in various soils. Microbiol Ecol 43, 26-33.

Berezovskaya, S., Daqing, Y., Hinzman, L. (2005) Long-term annual water balance analysis of the Lena River. Global and Planetary Change, 48, 1-3, 84-95.

Cao, M., Marshall, S., and Gregson, K. (1996) Global carbon exchange and methane emission from natural wetlands: application of a process-based model. *Journal of Geophysical Research* **101(D9)**, 14399-14414

Carini, S.A.; B.N. Orcutt und S.B. Joye (2003) Interactions between methane oxidation and nitrification in coastal sediments. 20:355-374.

Corradi, C., Kolle, O., Walter, K., Zimov, S.A., and Schulze, E.D. (2005) Carbon dioxide and methane exchange of a north-east Siberian tussock tundra. *Global Change Biology,* **11**, 1-16

Fiencke, C., E. Spieck, and E. Bock (2005) Nitrifying bacteria. In D. Werner, and W. E. Newton (eds.), Nitrogen Fixation in Agriculture, Forestry, Ecology, and the Environment. Springer, The Netherlands, Dordrecht. 12: 255-276.

Friborg, T., Soegaard, H., Christensen, T.R., Lloyd, C.R., and Panikov, N. (2003) Siberian wetlands: where a sink is a source. *Geophysical Research Letters,* **30**, 2129

Fung, I., John, J., Lerner, J., Matthews, E., Prather, M., Steele, L.P., and Fraser, P.J. (1991) Three-dimensional model synthesis of the global methane cycle. *Journal of Geophysical Research,* **96**, 13033-13065

Gersper, P.L., V. Alexander and S.A. Barkley (1980) The soils and their nutrients. In: Brown, J., P.C. Miller, L.L. Tieszen, F.L. Bunnell (eds.). An Arctic Ecosystem. The coastal Tundra at Barrow, Alaska. Stoudsburg: Dowden, Hutchinson & Ross, 219-254.

Huttunen et al. (2001) A novel sediment gas sampler and subsurface gas collector used for measurements of ebullition of methane and carbon dioxide from a eutrophied lake. The Science of the Total Environment, 266, p.153-158.

IPCC (2001) Climate Change 2001: The Scientific Basis. URL: http://www.grida.no/climate/ipcc_tar/wg1/index.htm

Joabsson, A., and Christensen, T.R. (2001) Methane emissions from wetlands and their relationship with vascular plants: an Arctic example. *Global Change Biology* **7**, 919-932

Kutzbach, L., C. Wille, and G. Stoof (2004a), Micrometeorological measurements of energy, water, and carbon exchange between Arctic tundra and the atmosphere, in Russian-German Cooperation SYSTEM LAPTEV SEA: The Expedition LENA-Anabar 2003, Reports on Polar Research 489, edited by L. Schirrmeister et al., pp. 12-19, 46-54. Alfred Wegener Institute, Bremerhaven, Germany

Kutzbach, L., Wagner, D., and Pfeiffer, E.-M. (2004b) Effect of microrelief and vegetation on methane emission from wet polygonal tundra, Lena Delta, Northern Siberia. Biogeochemistry 69: 341-362.

Kutzbach (2005) The Exchange of Energy, Water and Carbon Dioxide between Wet Arctic Tundra and the Atmosphere at the Lena River Delta, Northern Siberia. PhD thesis. AWI Potsdam and University of Hamburg, pp. 125

Le Mer, J., and Roger, P. (2001) Production, oxidation, emission and consumption of methane by soils: A review. European Journal of Soil Biology 37, 25-50Marion, G.M., and C.H. Black. 1987. The effect of time and temperature on nitrogen mineralization in Arctic tundra soils. Soil Science Society of America Journal 51:1501-1508.

Liebner S and Wagner D (2006) Abundance, distribution and potential activity of methane oxidising bacteria in permafrost soils from the Lena Delta, Siberia. *Environmental Microbiology*, doi: 10.1111/j.1462-2920.2006.01120.x.

Makov & Bazhin (1999) Methane emissions from lakes. Chemosphere, 38, p.1.453-1.459.

McCown, B.H. (1978) The interactions of organic nutrients, soil nitrogen and soil temperature and plant growth and survival in the arctic. In: Tieszen, L.L. (ed.). Vegetation and production ecology of an Alaskan arctic tundra. New York: Springer, 435-456.

Nadelhoffer, K.J., Giblin, A.E., Shaver, G.R., and G.R. Laudre (1991) Effects of temperature and substrate quality on element mineralization in six arctic soils. Ecology 72:242-253.

Pfeiffer et al. (2002) Modern processes in permafrost affected soils. In: E.-M. Pfeiffer & M. Grigoriev (eds.) Russian-German Cooperation System Laptev 2000, The Expedition LENA 2001. Reports on Polar and Marine Research, 426, 21-41.

Roslev, P., and King, G.M. (1996) Regulation of methane oxidation in a freshwater wetland by water table changes and anoxia. FEMS Microbiology Ecology, 19, 105-115

Schimel, J.P., K. Kielland, and F.S. Chapin III 1996. Nutrient availability and uptake by tundra plants. In: Reynolds, J.F., Tenhunen, J.D. (eds.). Landscape function and disturbance in arctic tundra. Ecological Studies120. Berlin: Springer, 203-221.

Semiletov et al. (1996) Atmospheric carbon emission from Asian lakes: A factor of global significance. Atmospheric Environment Vol. 30, 10/11, p. 1.657-1.671.

Smith, L.C., MacDonald, G.M., Velichko, A.A., Beilman, W.D., Borisova, O.K., Frey, K.E., Kremenetski, K.V., and Sheng, Y. (2004) Siberian peatlands: a net carbon sink and global methane source since the early Holocene. *Science,* **303,** 353-356

Soina, V.S., Lebedeva, E.V., Golyshina, O.V., Fedorov-Davydov, D.G., Gilichinsky, D.A. (1991) Nitrifying bacteria from permafrost deposits of the Kolyma lowland. Microbiologia 60, 187-190, in Russian

Spott, O., Kobabe, S.; Kutzbach, L., Wagner, D. & Pfeiffer, E.-M. (2003) Patterned ground lakes and their function as sources of atmospheric methane. In: M. Grigoriev et al. (eds.) Russian-German Cooperation System Laptev 2000, The Expedition LENA 2002. Reports on Polar and Marine Research, 466, 51-57.

Spott, O. (2003) Frostmusterbedingte Seen der polygonalen Tundra und ihre Funktion als Quellen atmosphärischen Methans. Diploma thesis. University of Leipzig and Hamburg, pp. 125, May 2003

Van Cleve, K., and V. Alexander (1981) Nitrogen cycling in tundra and boreal ecosystems. In: Clark, E.E. and T. Rosswall (eds.). Terrestrial nitrogen cycles. Ecol. Bull. Stockholm. 33: 375-404.

Wagner, D., Kobabe, S., Pfeiffer, E.-M., and Hubberten, H.-W. (2003) Microbial controls on methane fluxes from a polygonal tundra of the Lena Delta, Siberia. Permafrost and Periglacial Processes 14: 173-185.

Wagner D and Bolshiyanov D.Yu. (2006) Russian-German Cooperation System Laptev, The Expedition LENA 2004. Reports on Polar and Marine Research, in press.

Whalen, S.C., and Reeburgh, W.S. (1992) Interannual variations in tundra methane emission: a 4-year time series at fixed sites. *Global Biochemical Cycles,* **6**, 139-159

Wille, C., S. Kobabe and L. Kutzbach, (2003), Energy and water budget of permafrost soils – long time soil survey station on Samoylov Island, in Russian-German Cooperation SYSTEM LAPTEV SEA: The Expedition LENA 2002, Reports on Polar Research 466, edited by M. N. Grigoriev et al., pp. 17-28. Alfred Wegener Institute, Bremerhaven, Germany

Wuebbles, J., and Hayhoe, K. (2002) Atmospheric methane and global change. *Earth-Science Reviews,* **57**, 177-210

4. Studies of periglacial landscape dynamics and surface characteristics studies in the western Lena Delta

4.1. Scientific background and objectives

Lutz Schirrmeister

Studies on the Late Quaternary history of the Lena Delta (Figure 4.1-1) were previously carried out in the frame of the Russian-German cooperation SYSTEM LAPTEV SEA between 1998 and 2002, and published in several papers (e.g. Schwamborn et al. 2002, Krbetschek et al. 2002, Schirrmeister et al. 2003). Based on these previous studies, new scientific questions arose that require the combination of already existing results with further field investigations.

Our group, based at a field camp in the north-western part of the Lena Delta (Figure 4.1-2), investigated permafrost sequences in sediment cores and exposures for palaeo-environmental construction and conducted studies on the characteristics of the thermokarst-affected landscape.

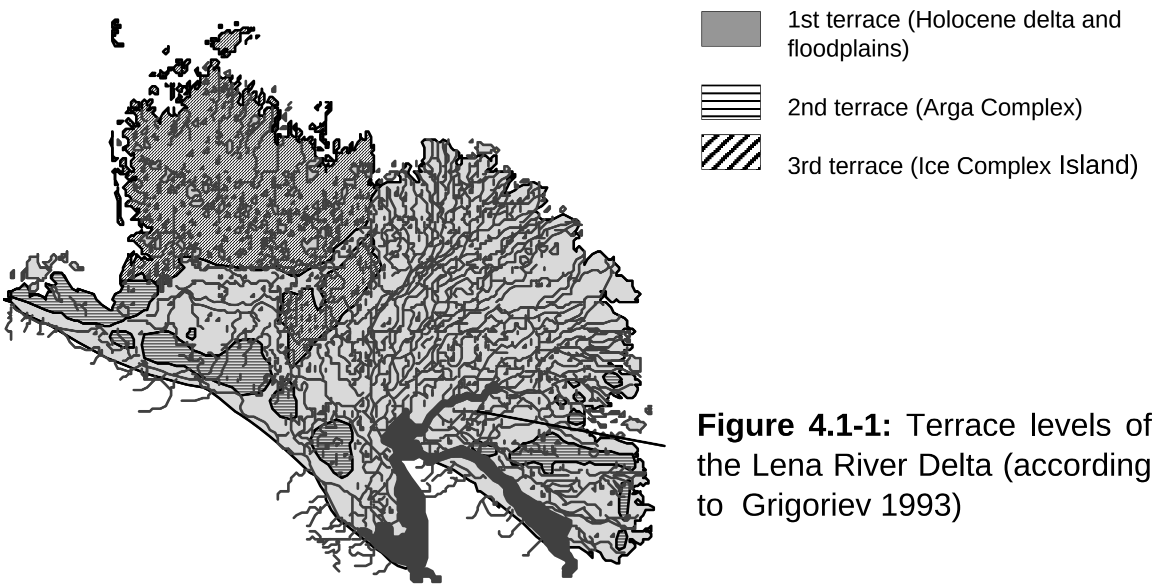


Figure 4.1-1: Terrace levels of the Lena River Delta (according to Grigoriev 1993)

One of the processes still unkown in the area is the genesis of the so-called “Arga-Complex”. The “Arga-Complex” is an extended sand complex, named after the largest island in the area – Arga-Muora-Sise. The deposits of this area, composing the 2nd terrace of the Lena Delta region were not accumulated under similar delta conditions like those of the 1st terrace of the Lena Delta formed in the Holocene (Figure 4.1-1). On the other hand the “Arga-Complex” is clearly distinguished from relicts of the Late Pleistocene Ice Complex formation of the 3rd terrace. Additionally, it is not clear, if the sand sequences forming the “Arga-Complex” could be facially and stratigraphically correlated with the sandy unit below the Ice Complex deposit along the Olenyekskaya Channel is not clear yet (Figure 4.2-1). Therefore the first objective was to descript the Quaternary history of “Arga Complex”.

The origin of the oriented lakes featured on the Arga-Complex is also under discussion since decades. Detailed geomorphologic (bathymetric and tachymetric) studies and surface observations would improve the understanding of the processes responsible for the formation of these lakes.

Finally, the study area features many different geomorphic units typical of arctic periglacial landscapes in Siberia. Their hydrological, sedimentological, morphological and botanical characterisation combined with the systematic measurement of spectral signatures will form the basis for the ground-truthing of multi spectral remote sensing data.

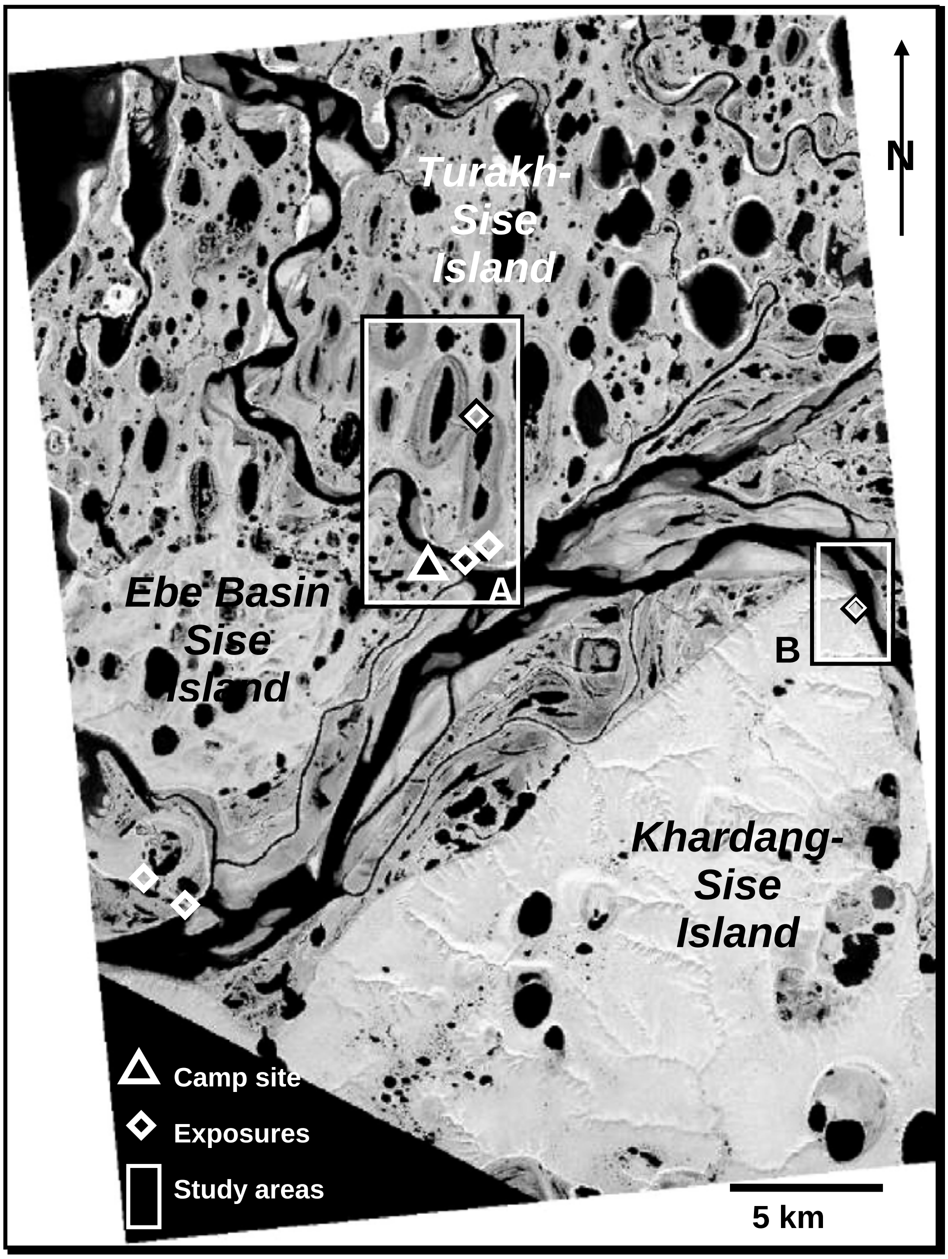


Figure 4.1-2: Study region in the western Lena Delta, (*Landsat T ETM+, July 24, 2001)*

4.2 Geological and geographical characteristics

Mikhael Grigoriev, Viktor Kunitsky, Lutz Schirrmeister

The study area, in the western part of the Lena Delta is bound to the east by the Tumatskaya Channel of the Lena Delta, to the south by the Chekanovsky Mountain Ridge, to the west by the Kuba Bay of the Laptev Sea, and to the north by the open Laptev Sea. Several islands in the western part of the Lena Delta, including Ebe-Basyn-Sise, Khardang-Sise, Dzhangylakh-Sise, and Kurungnakh-Sise are separated by the Bulukurskaya, Olenyekskaya, Arynskaya Channel, and other branches (distributaries) of the lower Lena River. The study area is characterised by the occurrence of the three typical terraces of the Lena River Delta (Figure 4.1-1).

- the 1st terrace (0-10 m a.s.l.): Holocene and modern delta floodplain, mostly along the main river channels
- the 2nd terrace (20-30 m a.s.l.): unclear origin; located in the north-western part of the delta
- the 3rd terrace (30-55m a.s.l.): remnant of a Late Pleistocene accumulation plain; located at the foot of the Chekanovsky Ridge.

The surface of the islands features complex Quaternary deposits. The composition and structure of these sediments have been described in a number of publications (Sachs and Strelkov, 1960; Gusev, 1961; Lungersgauzen, 1961; Grigoriev, 1966; Ivanov, 1972; Kolpakov, 1983; Galabala, 1987; Kunitsky, 1989). According to Galabala (1987), the sandy Muorinsky Suite (QII 1 – QIII 1) is totally covered by sands of the Turakhsky Suite (QIII 2) on Arga-Muora-Sise Island (Figure 4.2-1). The widely distributed sandy deposits, composing Arga-Muora-Sise Island, are correlated with the sandy unit exposed at the Olenyekskaya Channel below the Ice Complex unit (Figure 4.2-1).

New data on the composition and structure of Quaternary deposits from the mouth of the Lena River were obtained in the frame of the Russian-German cooperative scientific project “System Laptev Sea 2000” from 1998 to 2004 (Rachold and Grigoriev, 1999, 2000, 2001, 2003). Age determinations of a sandy sequence near the Lake Nikolay on Arga Island show that the sandy deposits at depths of about 1 to 4 m were formed between 14.5 and 10.9 ky BP (Krbetschek et al., 2002; Schwamborn et al., 2002). Whereas the sand unit below the Ice Complex along the Olenyekskaya Channel was accumulated between 60 and 100 ky before present (Schwamborn et al., 2002, Schirrmeister et al. 2004).

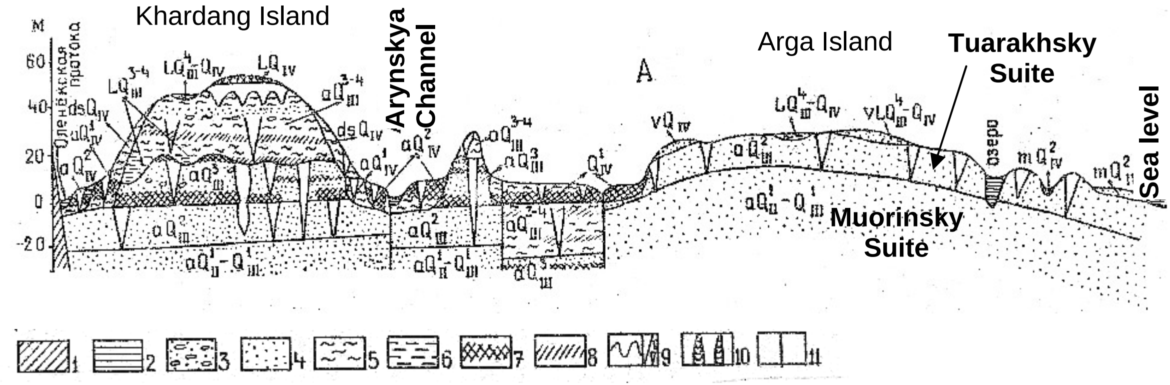


Figure 4.2-1: Schematic Profile of Quaternary deposits in the western part of the Lena Delta (Galabala 1987)

1 – Precenozoic basements; 2 –Paleogenic deposits; 3 – pebble horizon, conglomerate; 4 – Sands und pebble bearing sands; 5 – Loams and silts; 6 – Clays; 7 – peat; 8 – peaty silt and loam layers; 9 – Syngenetice ice wedges; 10 – Sediment-blocks within ice; 11 – Faults.

The genesis of the Arga Complex has thus yet to be fully explained. Opinions differ and call on marine, lagoonal, limnic-alluvial, alluvial-aeolian origin or glacifluvial, fluvio-nival accumulation to explain its occurrence. The most realistic hypothesis invokes the fluvial formation of old Lena River branches (Grigoriev 1993, 2000, Schwamborn 2000). The position of the Arga Complex is explained by tectonic uplift during the Late Quaternary (Are & Reimnitz 2000). Nevertheless the stratigraphic relations of “Arga sands” forming the 2nd terrace with the sandy sequences covered by Ice Complex deposits of the 3rd terrace have yet to be explained.

4.3. Studies of oriented lakes and thermokarst depressions

Hugues Lantuit, Mikhael N. Grigoriev, Guido Grosse and Mathias Ulrich

4.3.1 Background

Arga Island's morphology is ubiquitously characterized by the presence of elongated lakes up to 8 km wide and 6 km long. These lakes, like many others described in other parts of the Arctic, are ellipsoidal and oriented along a common direction, which grants them the denomination "oriented lakes". The axis of the Arga lakes is typically submeridional, (i.e. NNE-SSW) and their maximum water depth is in the range of 10-30 m (Grigoriev, 1993). The lakes feature deep large basins surrounded by shallow submerged rims, generally not deeper than 2m, and extending sometimes as much as 1km offshore.

Many hypotheses compete to explain the lakes' peculiar shape in Arctic landscapes. The supporters of the "wind hypothesis" argue that the wind is the prevailing agent in the formation of the elongated shape, which must be correlated to the wind dominant direction (Cote and Burn, 2002; Carson, 2001). Other authors (Pelltier, 2005) argue that the orientation of the lakes is mostly due to the general inclination of the relief over large distances. Grigoriev (1993) believes that the central lake basins on Arga Island are fluvial, lagoonal or deflation depressions that have been modified by periglacial processes, such as thermokarst. Are and Reimnitz (2000) think that a thawing of excess ice in the subsurface could have induces enough thaw settlement under the lake basins to lead to the present bathymetry. However, no discrete ice bodies have been detected yet in the Arga Island area to confirm this hypothesis. Schwamborn (2000), using a multidisciplinary and focused approach on Lake Nikolay, the largest lake on Arga Island, concluded, that "small ponds in abandoned fluvial pathways […] extended in depth and size due to thermokarst processes promoted in the ice-poor sandy subsurface".

The general lack of conclusive and extensive data on lake genesis in this region prompted the need for additional studies based on multiple approaches.

4.3.2 Study area

The latest field study concerned with lake genesis in the area focalised on the northern part of Arga Island, and in particular on Lake Nikolay, the largest lake on Arga Island (Schwamborn, 2000). Our study was therefore purposely located in the southern part of the "Arga Complex", in the vicinity of the Expedition Lena 2005 base camp, in order to compare both settings in our analyses and provide additional data to confirm or inform Schwamborn's hypothesis (2000) as well as to provide ground-truth data for satellite imagery (see section 4.3). We chose to focus on five depressions located on Turakh and on Ebe-Sise Islands. Three of these depressions are filled with lakes that are interconnected and drain into the Arinskaya Channel of the Lena Delta, The fourth depression is not connected with other lakes and does not drain into the Lena Delta channels. The fifth depression was located directly near the Arinskaya Channel (Figure 4.3-1). We named these depressions 1, 2, 3, 4, and 5 for practical purposes although these carry local names. The lakes located within the depressions inherited the numbers of the enclosing depressions.

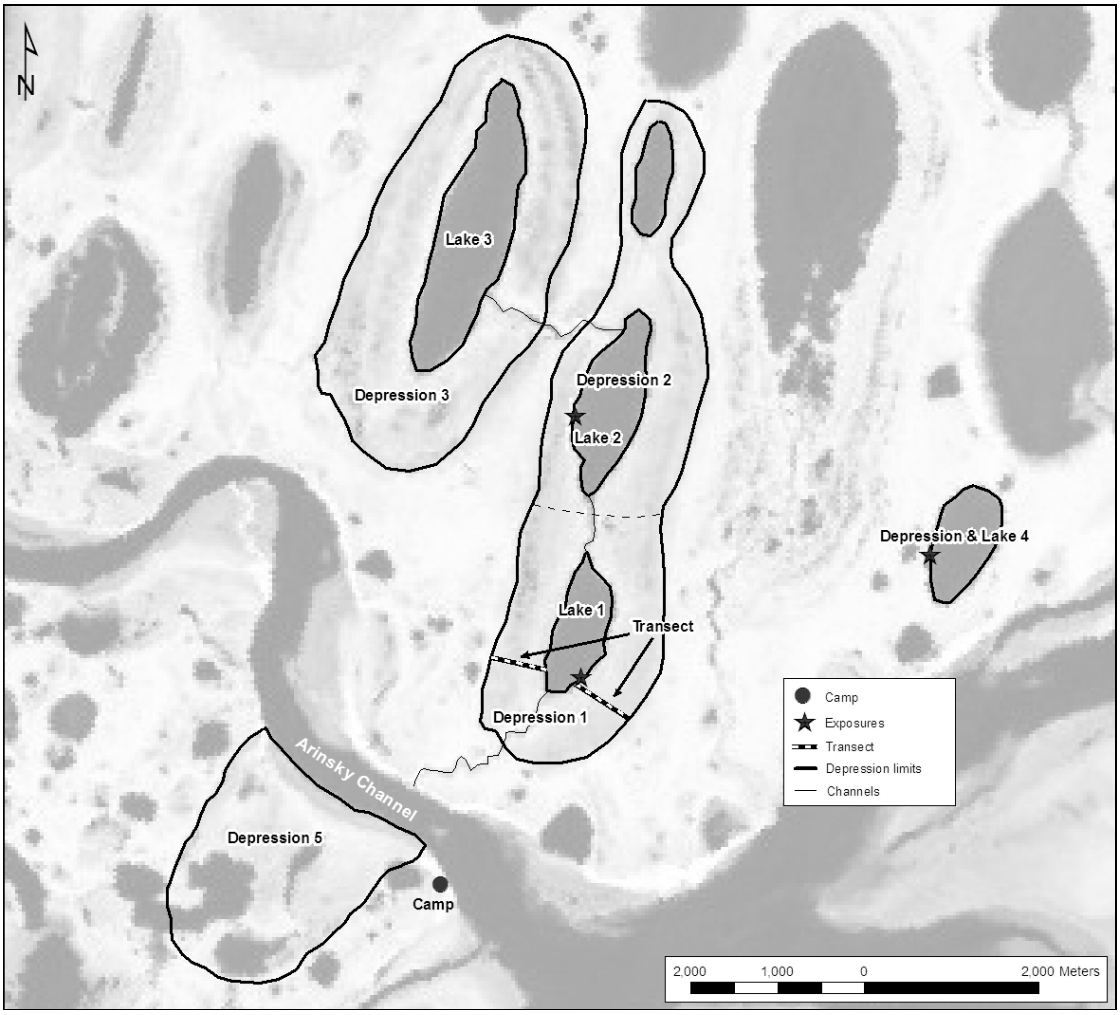


Figure 4.3-1: Study area and Lake nomenclature. The background image is a greyscale version of a Landsat color composite.

4.3.3 Topographical and geomorphological settings

4.3.3.1 Depressions 1, 2 and 3

Lakes 1 to 3 feature the same orientation that is a 20° inclination to the north. They are long and ellipsoidal and are interconnected. Lake 1 drains into lake 2 from its north most tip to the southern most tip of lake 2. Lake 2 drains into lake 3 from its north-western side shore to the western shore of lake 3. Lake 1 drains into the Arinskaya Channel at its southern most tip.

Table 4.3-1: Lakes geometrical features,

	Length (m)	Width (m)	Maximum recorded depth (m)	Length/ Width ratio	Direction of ellipsoid's main axis (°)
Lake1	1180	470	3.0	2.5	25
Lake 2	1580	540	9.5	2.9	25
Lake 3	2500	620	9.5	4.0	30
Lake 4	1010	500	3.3	2.0	30
Depression1	2110	1320	na	1.6	25
Depression 2	2250	1230	na	1.8	25
Depression 3	3730	1610	na	2.3	30
Depression 5	1790	1510	na	1.2	40

na= non applicable

These three lakes are located into much larger (up to 1.6 km wide and 3.7 km long) interconnected ellipsoidal depressions. Concave stabilized cliffs of dry sand at the surface generally bind these depressions. The slope within the depressions between the foot of the cliff and the shore of the lakes is generally gentle and regular. The inside surface of the depressions is characterized by very moist to flooded ground surface.

Within the depressions, tundra polygon rims are distinguishable and are often double ridges are visible. These ridges are generally 30-40 cm higher than the surrounding ground level. These ridges create closed polygons ponds often flooded by 10 to 30 cm of water. The spacing between polygons ridges varies between 10 m in the driest areas and much greater spacing (> 20-30 m) in moister areas. Often a subtle change from double to single rims is distinguishable on these features. Single ridges are of similar height but are longer and sinuous and can extend over hundreds of meters in a direction subparallel to the lakeshore without intersecting any other ridge. They also create bound areas, which are flooded by 10 to 30 cm of water. These features are detectable on high-resolution satellite images and form sub-concentric circles around the lake between the shore and the foot of the cliff closing the depression.

Evidence of runoff is hardly visible within the depression. However, multiple water outputs from polygon edges at the shore showed us that water was draining into the lake from the surrounding depression. In addition, soil investigations at the cliffs surrounding the depressions brought us visible evidence that groundwater input from higher grounds was important (Figure 4.3-2).

Figure 4.3-2: An example of the significance of the permafrost table upon groundwater motion. This particular example taken at the top of the Arga sands formation at the location marked "camp" in figure 4.3-1

We conducted a topographical survey using a Trimble tachymeter in order to obtain a complete topographical transect of a depression. The survey was conducted in depression 1 in E-W direction, along the small axis of the lake ellipsoid (Figure 4.3-1). Survey marks were collected approximately every 20 m. In addition, the base mark of the survey was measured later from the shore of the Arinskaya Channel in order to obtain the elevation of the lake water level above the Arinskaya Channel. The resulting transect is shown in Figure 4.3-3.

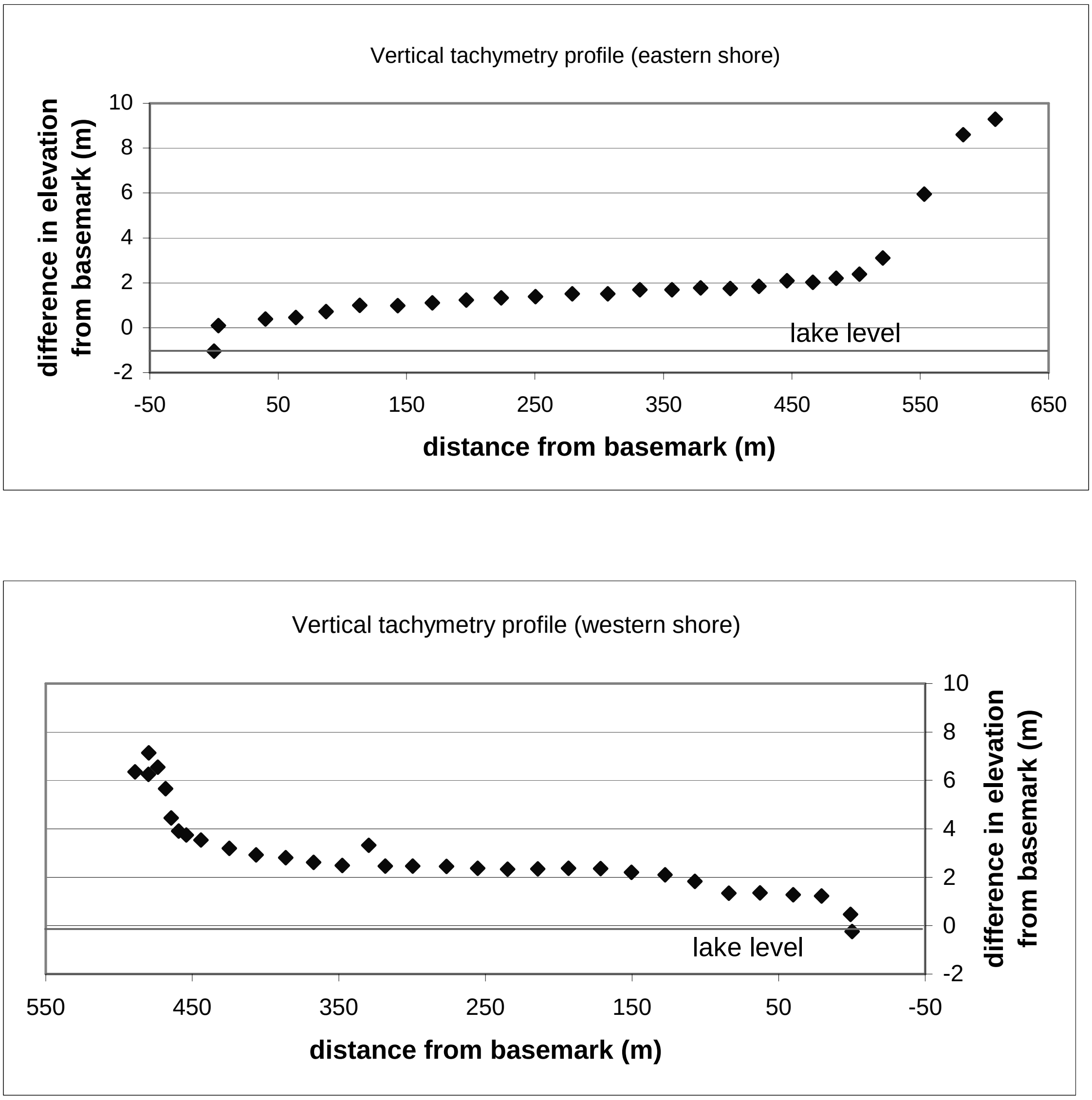


Figure 4.3-3: Vertical tachymetry profile of depression 1

Lakes 1, 2, and 3 are connected by narrow (< 10 m wide channels) where no evidence of the direction of the flow can be detected (Figure 4.3-4).

Figure 4.3-4: Upper part of channel connecting Lake 1 to the Arynskaya Channel

We observed two apparent opposed flow directions from one day to another under changing prevailing wind directions for the channels between lakes 1 and 2 and lakes 2 and 3. In addition, bathymetrical survey indicated the presence of underwater fans at both outlets for the three channels (chapter 4.3.4).

The channel between lake 2 and 3 flows in a narrow valley cut into the surrounding high grounds. Sandy cliffs up to 10 m high are exposed on the thalweg sides. The valley is approximately three to four times larger than the width of the channel at the time of the investigation. Since depressions 1 and 2 are merged into one single large depression, the channel between lakes 1 and 2 lays in a relatively low-lying setting, that is, similar to the rest of the depression surface, only surrounded by slightly elevated (< 2 m high) low-angle convexo-concave vegetated slopes.

The channel draining lake 1 into the Arynskaya Channel is constituted of two parts. The first one corresponds to the section of the flow located into the larger depression 1, and the second to the part located between the border of depression 1 and the Arynskaya Channel.

The first section of the flow is between 5 and 10 m wide. The channel is located into a wider topographically depressed channel, approximately 50 m wide, mostly vegetated, and characterized by the presence of polygonal grounds. The direction of the flow is also hard to detect in this section and strongly dependent on the direction of the wind.

The second section of the channel is less than 5 m wide, and flows for most of the distance as a narrow (< 2 m) channel. The flow is clearly directed towards the Arinskaya Channel and located in a narrower valley (< 20 m wide). The valley sides are steep and often non-vegetated or affected by slumping.

Driftwood is randomly distributed in depressions 1 and 2, from the bottom of the surrounding cliffs to the lake shore. We found driftwood logs as long as 5 m within these depressions. No driftwood was found in depression 3. Driftwood occurrence was greater in the channels connecting the lakes, including the channel connecting lakes 1 to 2, lakes 2 to 3, and the channel connecting lake 1 to the Arinskaya Channel. In the latter channel, huge logs, probably not older than fifty years and up to 20 m long were found in the depressed area surrounding the channel in its upper section (Figure 4.3-5).

Figure 4.3-5: Log found in the flanks of the channel connecting lake 1 and the Arinskaya Channel.

We observed the occurrence of several, mostly non-vegetated discrete fine sediment deposits, 2 to 4 m wide both in depressions 1 and 2 and in the channels connecting the depressions (Figure 4.3-6). The deposits were generally about 20 cm thick and lay over the surrounding vegetation. Because the vegetation buried by these deposits was often not at a dead stage, we concluded that these deposits were recent and probably deposited here by the spring floods of the Lena, and in particular by large ice fragments covered by sediment from the early flood.

Figure 4.3-6: Localized deposit of fine sediment overlying vegetation in the channel connecting lake 1 and the Arinskaya Channel

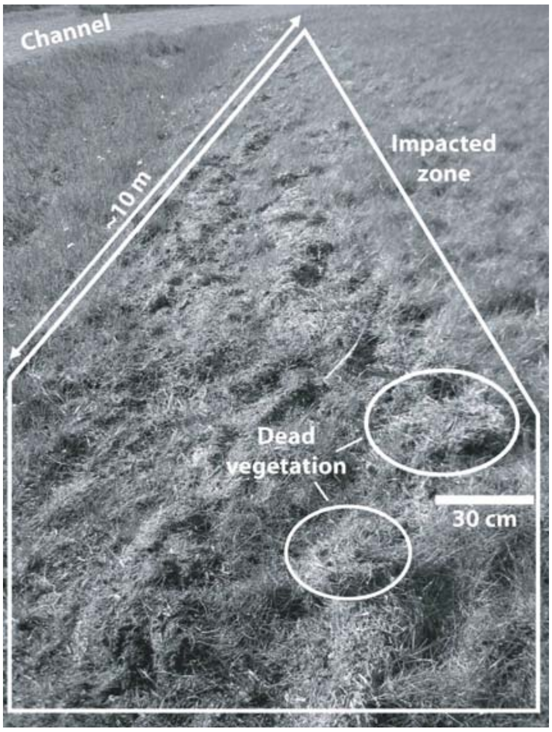


Figure 4.3-7: Deposit of dead vegetation on the flanks of the channel connecting lake 1 and the Arinskaya Channel

Within the depression surrounding the channels connecting lake 1 to lake 2 and lake 1 to the Arinskaya Channel, traces of destruction of the vegetation over tens of metres along a direction subparallel to the channels were observed. These traces were generally accompanied by the presence of recently degraded grass and small driftwood pieces along the path (Figure 4.3-7).

We think that these traces are also due to incoming ice during spring flood. A detailed investigation of satellite imagery further ascertained that depressions 1, 2, and 3 were flooded during spring floods (Figure 4.3-8).

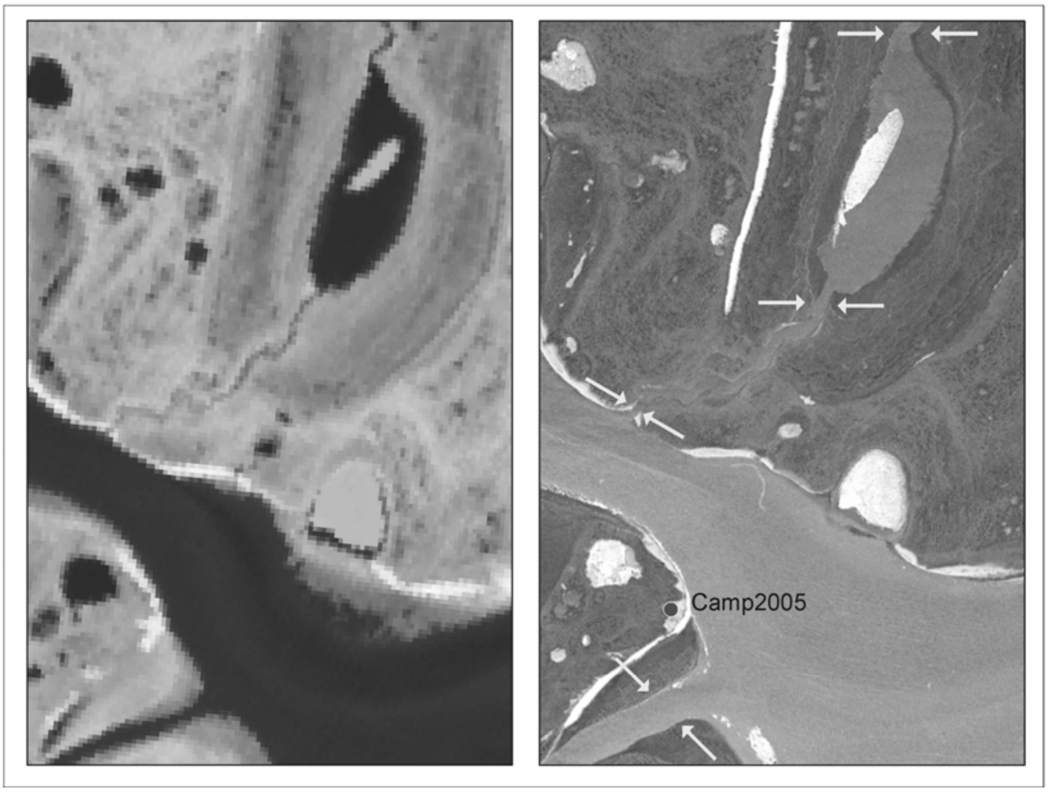


Figure 4.3-8: Water levels during summer (left) and during spring flood (right) for depression 1 (Left: 2005 late summer Chris Proba image; right: Archived 1970's mid-June Corona image)

Figure 4.3-9: Crescentic dunes on the top of the shore cliffs of lake 2 (29/08/05).

4.3.3.2 Depression 4

Depression 4 was chosen because, contrary to depression 1, 2, and 3, it has no obvious connection to the Lena Delta channels. Also, depression 4 is entirely filled by a lake and considerably smaller than depressions 1, 2, and 3. Depression 4 is approximately 1010 m in length and 500 m in width. Its shape is rounder than the ones of the other depressions. The shores around lake 4 range between 0.5 to 3 m in height. On the western side of the lake, the shore material is exposed and consists mostly of a mixture of buried soils and sand overlying a thick sandy formation. No driftwood of discrete deposits such as the ones described in depressions 1 and 2 were found around lake 4.

4.3.3.5 Depression 5

Depression 5 is located on the Ebe-Sise Island, on the south-west shore from the Arinskaya Channel. Its shape is generally ellipsoidal, although rounder than the other depressions and intersected on its north-east side by the Arinskaya Channel. Depression 5's bottom floor is also flatter than the ones of depressions 1, 2, and 3 and lays at a lower elevation. The north-east border of the depression is delimitated by a levee, approximately 0.5 m higher than the rest of the depression floor and 2 m higher than the flat sand surfaces in the riverbed. The levee is dryer than the rest of the depression, and covered by driftwood. Down this levee and next to the Arinskaya Channel, several isolated deposits of fine sediments, 20 to 30cm thick and lying over green buried vegetation were observed. We assume that these deposits are due to the melting of ice floes, similar to the ones described in depression 1.

The levee itself is steep and convex on the riverside and shows signs of vegetation destructions tracks, probably due to floating ice fragments.

Depression 5 is constituted of typical polygonal surfaces and small lakes. In contrast with depressions 1, 2, and 3, these lakes are not characterized by a common orientation and their shape are not ellipsoidal. In addition, they are not located in the centre of the depression, but rather randomly distributed. Observations from satellite imagery gave us indication that the depth of these lakes might be considerably lower than the ones observed for instance for lakes 2 and 3. We saw no indication of sub basins within the lake floor on satellite imagery. The depression is bound landwards by convexo-concave well-drained walls constituted mostly of sandy material. The overlying environment is one of dry sandy tundra and hummock-like non-sorted patterned ground.

Polygonal grounds into the depression are characterized by concentric to sub-concentric patterns. Immediately below the bounding walls, long polygon edges parallel to the walls can be observed expressing an overall radiant pattern for the entire depression. In centre parts of the depression, however, concentric to sub-concentric patterns can be observed around isolated ponds or lakes, which leads us to believe that these lakes are probably present since the depression was drained. The ground is generally very moist and the active layer is shallow (30-40 cm). Several discrete mound occurrences were observed in the depression. These mounds, between 4 and 7 in width, sub-circular in shape and risen 30 to 50 cm above the surrounding floor were observed where no obvious connection with a specific landscape feature could be asserted. The core of these mounds was sampled in situ and will be analysed in the laboratory. Collected samples were ice-rich. No specific bubble orientation or layering in the ice could be observed.

4.3.4 Bathymetrical surveys.

We conducted several bathymetrical survey on lake 1, 2, 3 and 4 using a manual echolot sounder operated from a rubber boat. The soundings were captured together with coordinates so that the results could be displayed in a GIS. The results of the bathymetry survey are shown in Figure 4.3-10 on a map. Figure 4.3-11 is a S-N transect representation from lake 3 bathymetry.

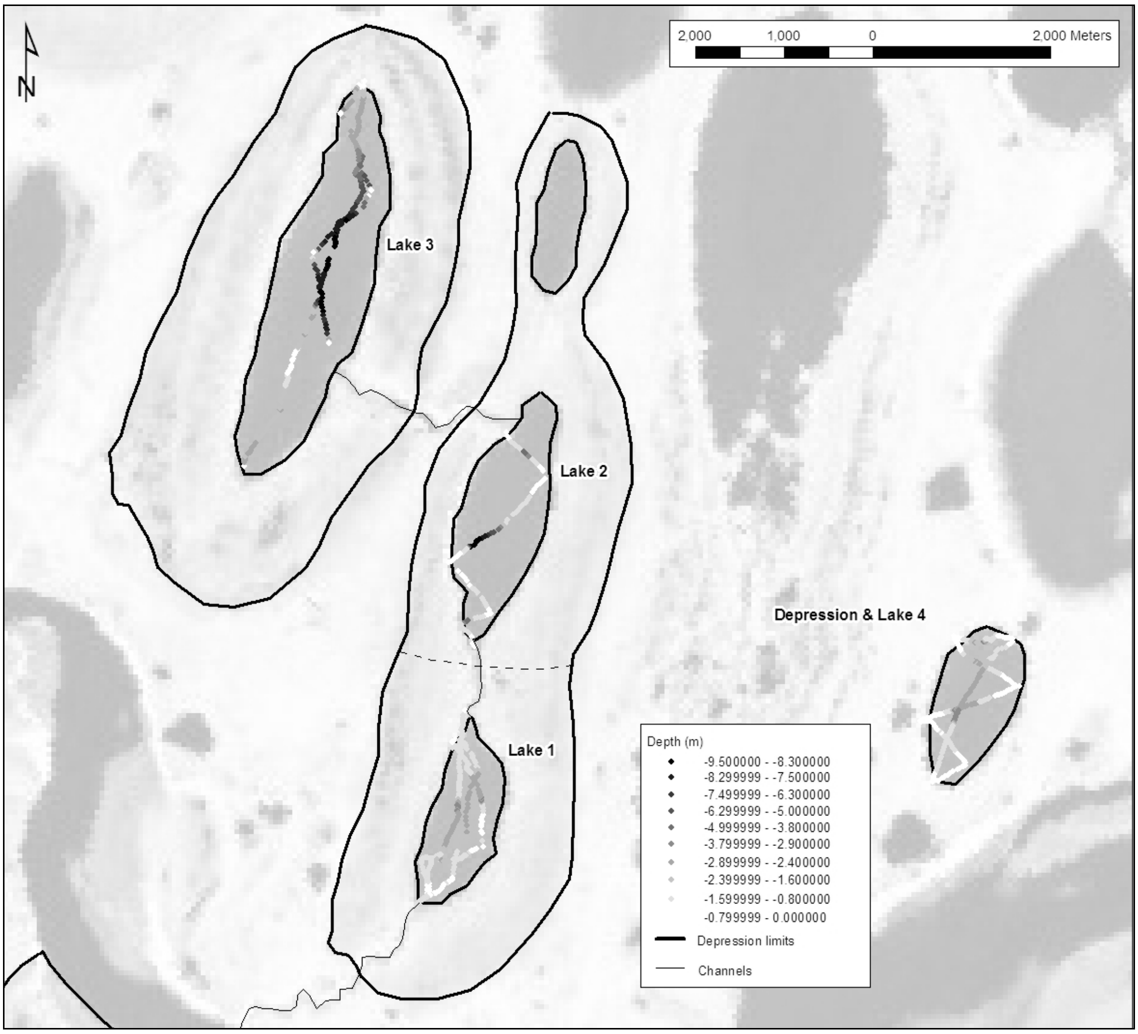


Figure 4.3-10: Map of bathymetric surveys

Figure 4.3-11: S-N bathymetric transect of lake 3

All four lakes featured three common elements:

1) a shallow platform (~1m deep) extending from the shore offshore,

2) a secondary and much more extensive platform (~2.5 m deep) extending from the limit of the first platform to the limit of the third element, and

3) an area characterised by deeper and non-flat grounds extending as much as 9.7 m deep in some lakes.

The latter element differed greatly from one lake to the other. Lake 1, for instance was found to extend only up to 3.3 m depth, while lake 3 extended as much as 9.7 m depth. Lake 4, unlike lake 2 and 3 was found to be shallower (up to 3.3 m). This scheme is consistent with the descriptions of Lake Nikolay's underwater topography by Schwamborn et al. (2000).

Lake 3 featured two deeper (deeper than 2 m) areas separated by much shallower ground in the central part of the lake. These shallower grounds were located immediately at the outlet of the channel connecting lake 3 to lake 2 and could be linked to the influx of sediment from spring floods, as hypothesised in section 4.3.6.

During the bathymetrical surveys, water samples were collected to obtain the isotopic signature of the lake water and compare it to the one of the Lena River (Tur-Lake-10-W1; Tur-Lake-10-W2)(Appendix 4-2).. The water samples were acquired in the middle of the lakes.

4.3.5 Field sampling

In order to get an insight into the genesis of the depressions, exposed sections within the depressions were investigated and sampled. Additionally, isolated samples were collected from driftwood and discrete sediment deposits. Sampling positions are listed and mapped on Figure 4.3-1 as star figures. Additional soil profiles were investigated in these depressions but are fully described in chapter 4.4. in this report. Three exposures were investigated in detail. The first one was situated at the eroding shore of lake1, the second at the eroding cliffs on the western shore of lake 2 and the third on the western shore of lake 4. An example of one of these sections in given in Figure 4.3-12

Figure 4.3-12: Soil exposure at lake 4 showing the strong contrast between the overlying succession of buried soils and the underlying monostructural and well-sorted sands

The isolated samples collected in the depressions consisted mainly of driftwood or sediment samples. Three driftwood samples at different levels of burial in the depression floor were collected in the southern part of depression 1.

The discrete fine sediment deposits observed in depression 1 and in the depressions surrounding the channels connecting the lakes 1 to 2, and 1 to Arynskaya Channel were also sampled.

Finally the “ice-cored mounds” observed in depression 2 and in depression 5 were sampled to establish ice content and to conduct sedimentological analyses.

4.4 Characteristics and spectral properties of periglacial landforms

Mathias Ulrich, Guido Grosse

4.4.1 Introduction

Remote sensing imagery is an excellent tool for the characterization of Arctic permafrost landscapes on large scales. Nevertheless, the successful interpretation of multispectral- and hyperspectral remote sensing data of spatially complex Arctic permafrost landscapes requires considerable field work for ground truth. This includes the acquisition of data on vegetation, soils, geomorphology, and also spectral surface properties.

A Landsat-7 based landcover classification for the entire Lena Delta was conducted by Schneider (2005). For this classification a Landsat-7 image mosaic of 3 scenes from 2000 and 2001 was used. The goal of this classification was the characterization and quantification of surface units and their usability for the up-scaling of locally measured methane emissions. The approach was based on available field data from several expeditions. Finally, 12 broad landcover classes could be differentiated. Several difficulties for the classification were encountered especially in delta regions with sparse field data. To overcome these difficulties and enhance the classification and results from it, more imagery from Landsat-7 and CHRIS Proba was acquired and additional field work was conducted during in 2005.

We collected extensive ground truth data in the central and western Lena Delta, NE Siberia, during the joint Russian-German expedition “Lena Delta 2005”.

The two main goals of our field work were:

- To provide the basic ground truth information necessary for the general characterization and classification of periglacial surfaces and geomorphological units in the Lena Delta by their spectral properties
- To provide ground truth data necessary for testing the application of hyperspectral data (field spectrometry and CHRIS Proba imagery) for the characterization of periglacial tundra landscapes

4.4.2 Methods

The delta is subdivided into three geomorphological terraces, which distinctly differ in their cryolithological, hydrological and geomorphological properties. These differences result in characteristic surface properties for the main units mainly influenced by hydrology, soils and vegetation composition. Our intent was to use the spectral variations between different land surface types to differentiate the major geomorphological units in the investigation area and conduct a file data based landcover classification.

Beyond general geomorphological mapping and description of surface properties, we used a portable field spectrometer to collect spectral data of a variety of typical periglacial surfaces in the central and western delta (Figure 4.4-1).

The field reflectance spectra were acquired in the spectral range 350 - 2500nm applying an ASD FieldSpec FR® Pro (Analytical Spectral Devices Inc.) (see Table 4.4-1 for instrument details). Usually the measurements were conducted on clear sky days around solar noon during August 2005. The data were acquired following procedures for calibration and referencing with a Spectralon® white panel (Labsphere, Inc.). For the acquisition of 1 spectrum a scanning time of 5 seconds was applied. Thus, according to the scanning time of the instrument (100ms) (Tab. 4.4-1), each acquired spectrum represents an averaging of 50 individual measurements. First, this procedure increases the signal-to-noise ratio of the instrument. Second, when the operator is moving forward during the 5 sec recording process, the resulting spectral signal is integrated over a larger field of view more representative for the typical heterogenic periglacial surfaces in the investigation area.

Table 4.4-1: Technical notes for the ASD FieldSpec®FR Pro

Spectral range	350 - 2500nm
3 detectors	VNIR: photo-diode array (350-1000nm) SWIR 1: scanning spectrometer (1000-1770 nm) SWIR 2: scanning spectrometer (1770-2500 nm)
Wavelength accuracy	±1nm
Ground resolution	- Variable (dependent on chosen fore optic and the distance between fore optic and ground) - We used bare optics (24° field of view) and an altitude of 1m, resulting in a circle of about 0.2m radius
Spectral resolution	3nm for 350-1000nm 10-12 nm for 1000-2500 nm
Data channels	512 for 350-1000nm 1060 for 1000-2500 nm interpolated data points: every 1nm (2151 total)
Field of view	Variable (dependent on chosen fore optic): 24° (bare optic), 1° or 8° (fore optic lenses)
Data acquisition	1 scan every 100ms (0.1s) (scans can be averaged to increase signal-to-noise ratio)

Figure 4.4-1: Field spectrometry in the Lena-Delta. Calibration of the spectrometer using a Spectralon® white panel.

During the field work we carried out point and profile measurements with the spectrometer. Altogether, 19 sites were investigated:

Samoylov Island – 4 sites

Kurungnakh Island – 2 sites

Turakh-Sise Island – 2 sites

Ebe-Basyn-Sise Island – 11 sites (main investigation area in the western delta).

For each location, soil properties, active layer depths, geomorphological situation, and vegetation properties were recorded. More detailed information on the investigation sites are summarized in Appendix 4-1.

4.4.3 First results

During the field season 2005 more than 500 field spectra were acquired in the Lena Delta. A first assessment of the field spectra indicates a good spectral separability of the delta main terraces and thus significant differences in surface properties. Spectral differences in micromorphology (e.g. differentiation between polygon rim and centre) were also detected in the spectra. Main factors of the differences are vegetation composition, moisture content and vitality of vegetation cover. More advanced results of these investigations are summarized in the Diploma Thesis of Mathias Ulrich (Ulrich 2006).

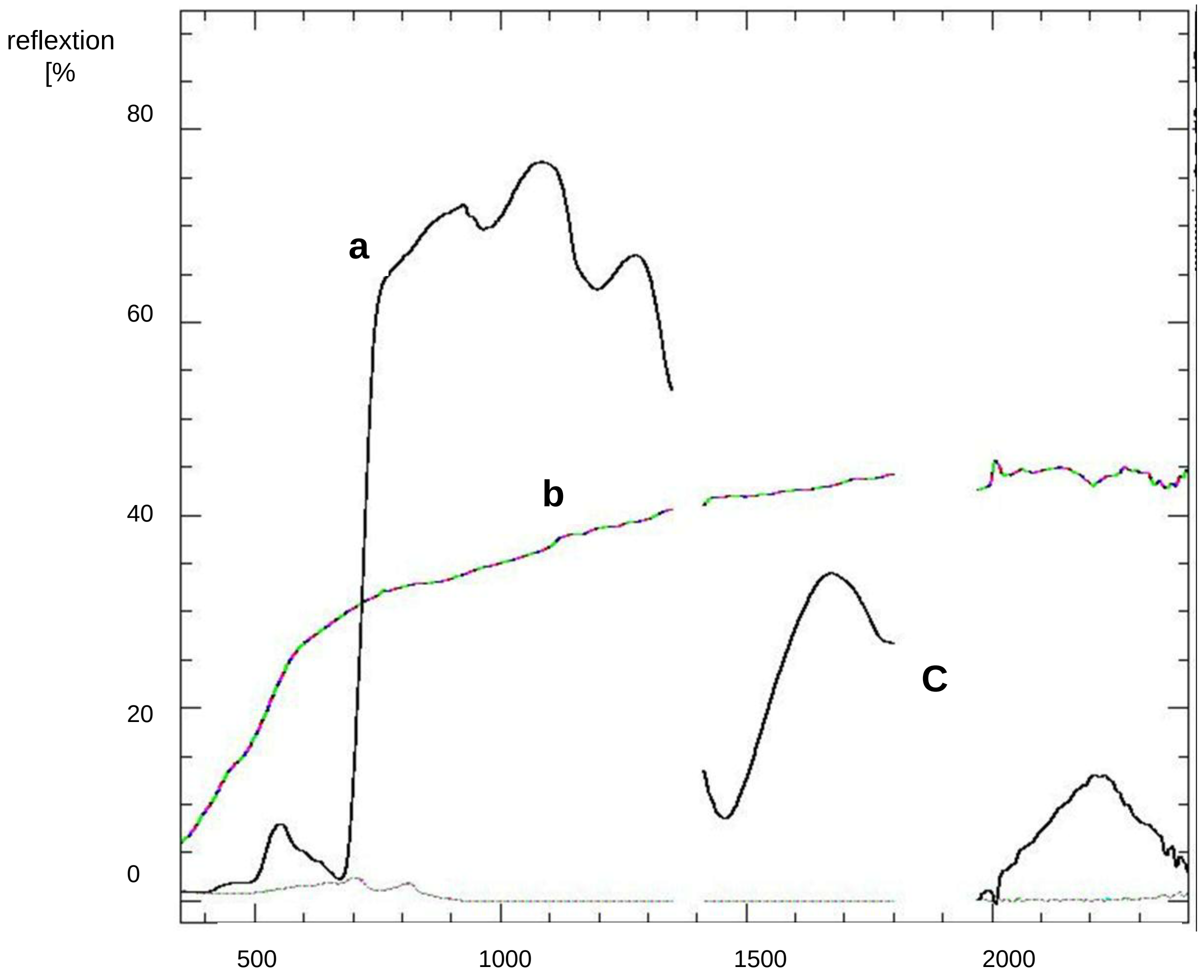


Figure 4.4-2: Exemplarily spectra of grass (a), sand (b), and water (c) of the study area

4.5. Studies of permafrost sequences for paleo-environmental reconstruction

4.5.1 The "Arga-Sands" on Turakh Island

Lutz Schirrmeister, Guido Grosse, Mikhael Grigoriev, Waldemar Schneider

In order to obtain a complete sediment profile of the sandy deposits, an exposure was studied on the left bank of the Arynskaya Channel. At this location, an outflow from an oriented lake located on Turakh Island (Fig. 4.1-1, chapter 4.3) flows into the Arynskaya Channel and exposes typical Arga-Complex sands. The exposure (Tur-1) was dug using shovels and cleaned with a scraper in order to reveal sediment and ice structures. The observed sedimentological and cryolithological features were described, drawn and photographed. 0.5 to 1.0 kg of frozen sediment was sampled using a hammer and a small axe for sedimentological, geocryological and paleo-ecological analyses. For age determinations using infrared stimulated luminescence method (IRSL), frozen samples were drilled with a hand-drilling machine (HILTI TE 5 A). A special drill head and opaque plastic cylinders as well as opaque plastic bags were used to protect the sample from sunlight exposure. Finally, samples of ground ice were collected for stable isotope and hydro-chemical analysis (see chapter 5) using ice screws or, for smaller ice bodies, only with a small axe. All samples are listed in appendix 4-2.

In order to obtain a thorough sediment profile of the "Arga-Sands", a 11.43 m deep borehole (Tur-2) was drilled immediately In front of the exposure Tur-1 using a 6 cm diameter permafrost coring kit powered by a 2.9 kW engine (TKB-15, Fa. Lutz Kurth). The extracted cores were separated in 20 to 30 cm length bits. Most of them were retrieved in frozen state. Each core was then described, photographed and sampled every 10 cm. Approximately every meter, a core bit was sampled for ice content measurements. Gravimetric ice contents were then calculated using a relation to the dry weight of the samples.

Additionally, GPR surveys were carried out on top and bottom of the Tur-1 exposure (see chapter 4.6).

4.5.1.1 Exposure Tur-1 (72.97401° N; 123.79858° W)

The profile dug into the Arynskaya Channel bank exposed the entire 4.50 m high cliff (Figure 4.5.1-1). The lower (<2.00 m depth) part is composed of frozen sediment.

From 4.50 to 3.75 m depth, the profile shows cross-bedded fine- to medium grained sands, characterised by a massive cryostructure (samples Tur-1-S-1, S-15, S-16). Further up (3.75 – 3.25 m), fine-grained sand with small ice schlieres occur and feature diagonally-arranged ice structures. The uppermost frozen part of the profile (3.25 – 2.00 m) is characterised by the occurrence of brownish ice-rich sands with iron oxide impregnations, bands of humus enrichments and other indicators of soil processes (samples Tur-1-S-2 to S-6). The two latter horizons feature a specific type of ground ice: 10 to 20 cm wide ice-veins oriented both horizontally and vertically intersect to form a lattice-like structure. Although closer observations could hardly indicate which ground ice type it was, we acknowledged it as ice wedge ice, in reference to similar structures formerly investigated in Arga sands (Schwamborn et al. 2002c) (ice samples Tur-1-I-1 to I-15).

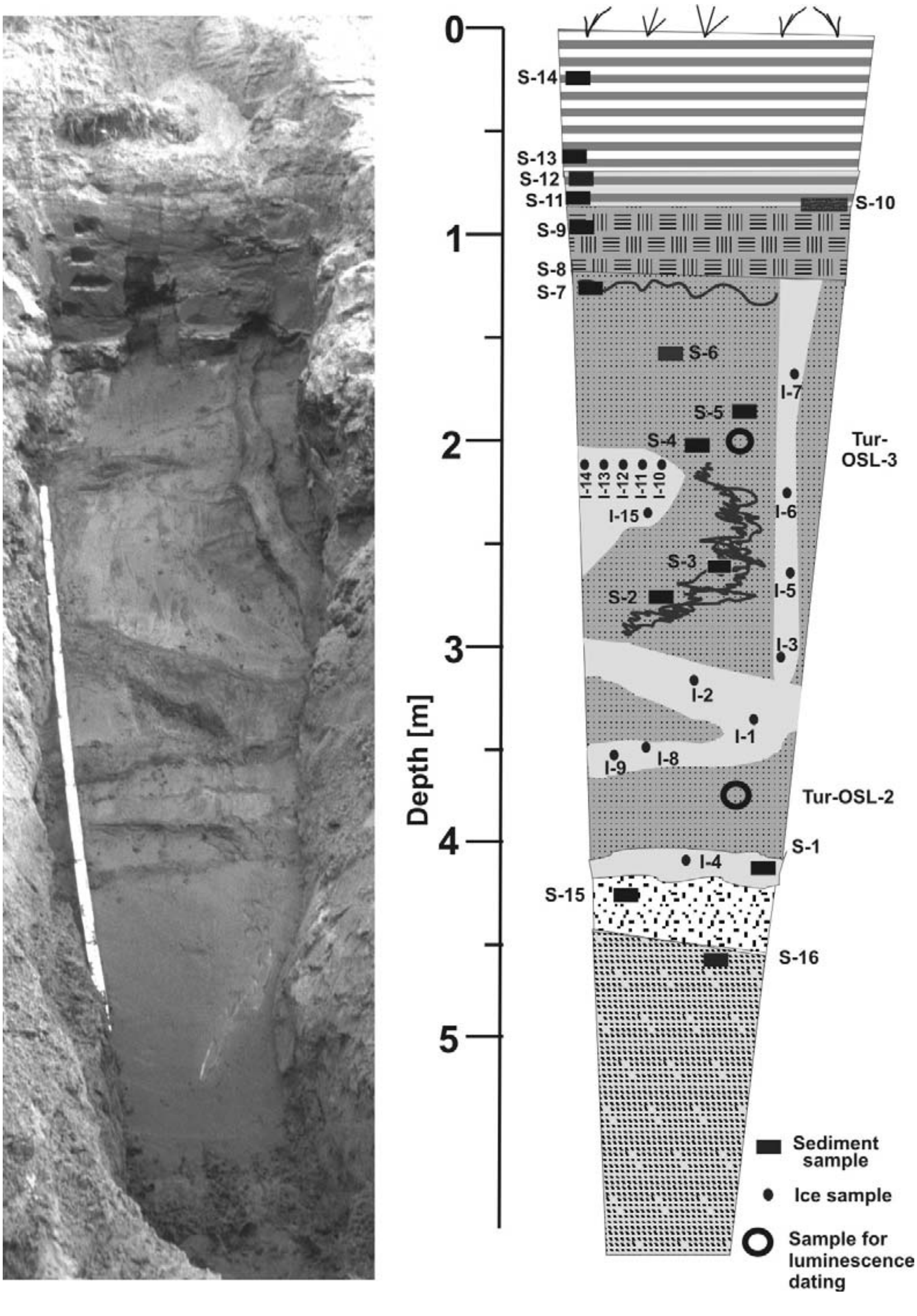


Figure 4.5.1-1: Outcrop scheme of the exposure Tur-1

The bottom part of the layer ranging between 3.25 and 2.00 m depth features a cryoturbated soil. His upper boundary corresponds with its upper permafrost table. An unfrozen peaty layer of 20 cm thickness in 1.2 – 1,0 m depth containing an wood stick covers the frozen sequence (samples Tur-1-S-7 to S-10). The next unfrozen horizon (1.0 – 0.8 m depth) is characterised by fine-layered alternation of thin (2-5 mm) brownish and grey lamina (samples Tur-1-S-11 to S 13). It looks like repeated aeolian covering of soil layers. The uppermost horizon of the exposure Tur-1 is composed of unfrozen well-bedded aeolian sand (dune) (sample Tur-1-S-14).

4.5.1.2 Core Tur-2 (72.974° N; 123.7986° W)

Lutz Schirrmeister, Guido Grosse, Mikhael Grigoriev, Waldemar Schneider

The 11.43 m deep borehole was drilled between August 20 and August 29 (Figure 4.51-2). The daily drill progress was about 2 to 2.5 m. The 20 to 30 cm long frozen cores were cleaned with a knife and then described (Table 4.5.1-1), sampled and packed in plastic bags as 5-10 cm long segments. The first meter consisted of unfrozen beach sand (Figure 4.5.1-3). The next half meter featured similar structures to the ones exposed in the lower part of the Tur-1 exposure, in particular a thin, vertical ice vein. The middle part of the core sequence (1.53 to 5.78 m) consisted of greyish, bedded, fine-, middle-, and coarse sand characterised by a massive cryostructure. IAt a 5.83 m depth, a second ice vein occurred in the core. Further down (5.88 to 9.79 m), the sediment color changed to more spotty orange brownish patterns, caused by iron oxide impregnations. In addition, organic-rich interbeds and plant remains such as twig fragments were visible. A lighter mica-bearing horizon was cored between 9.79 to 10.34 m depth. The lowermost part of the core (10.34 to 11.43 m) was characterised by numerous small black inclusions of probably coal fragments.

Figure 4.5.1-2: The drilling machine TKB-15 in front of the exposure Tur-1

In general, the gravimetric ice content varies between 20 and 40 wt%. with only two peak of ice-rich layers (Figure .4.5.1-3). Temperature measurements were carried out three days after finishing to drill using the resistance measurements of calibrated thermistors (MMT-4) of the Permafrost Institute Yakutsk.

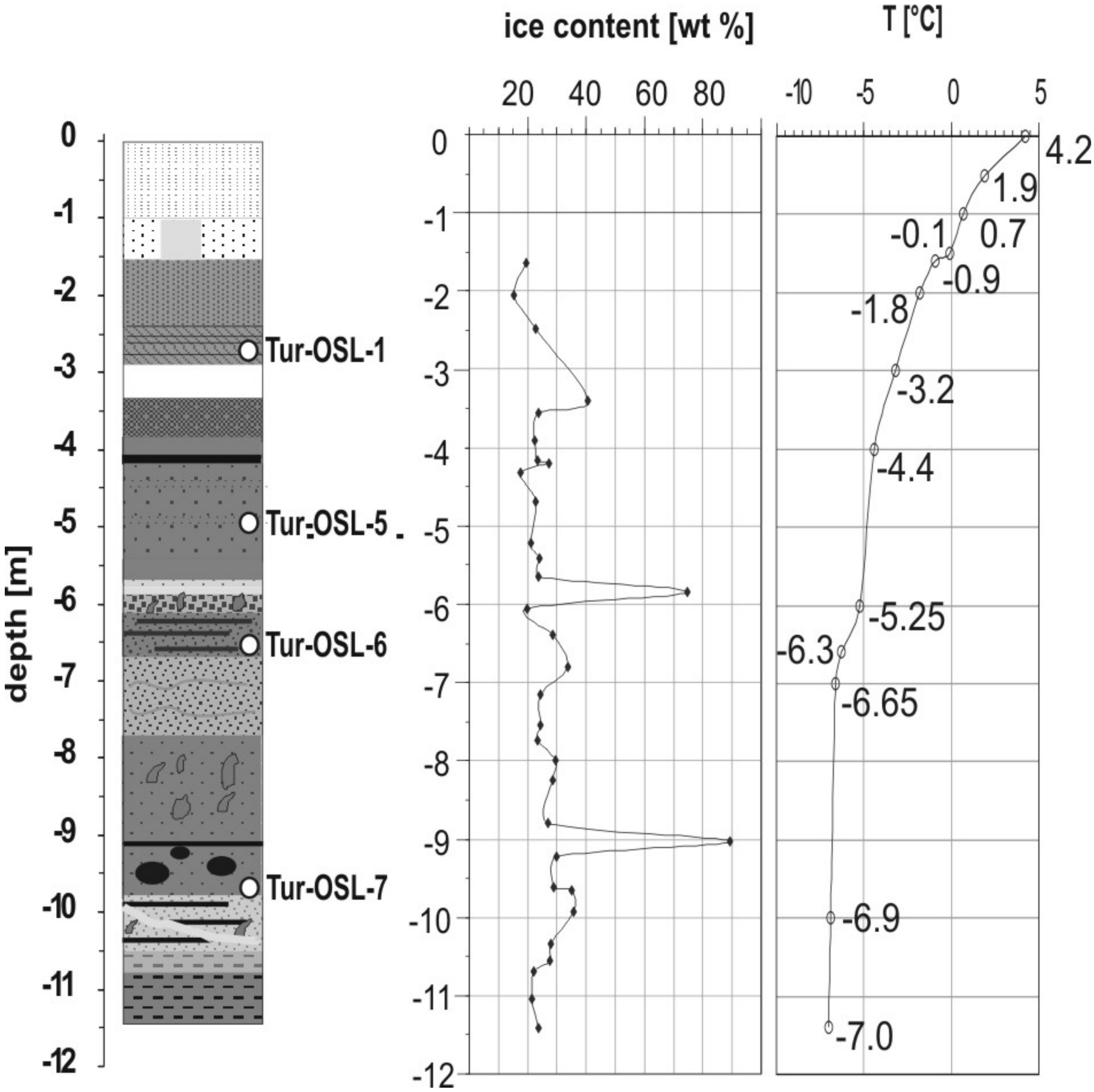


Figure 4.5.1-3: Schematic profile of the core Tur-2 with measurements recorded in the field, Temperature measurement was carried out in August 31, 2005

Tabble 4.5.1-1: Core description Tur-2

Depth [m]	Description
0.0 - 1.0 0	Beach deposits, active layer, unfrozen sand
1.00 – 1.10	Frozen fine sand, similar to the one exposed in the lower part of exposure Tur-1
1.10 – 1.53	Vertical ice vein, 2 cm wide, in frozen fine sand
1.53 – 2.40	Greyish brown sand, massive cryostructure
2.40 – 2.85	Cross-bedded sand, small silty interbeds, greyish-brown
2.85 - 3.35	*Core loss*
3.35 - 3.85	Fine sand to middle sand greyish-brown, Tur-OSL-1 (3.6-3.77 m)
3.85 – 4.25	Interbedded fine middle and coarse sand, 4.12-4.18 m: organic-rich layers
4.25 – 5.60	Fine and middle sand interbedding, Tur-OSL-5 (4.95 – 5.07 m)
5.60 – 5.78	Graded bedding, thin laminaes, fine sand, middle sand
5.78 – 5.83	Ice-rich sand
5.83 – 5.88	Ice vein, vertical gas bubbles
5.88 – 6.10	Greyish-brown middle to fine sand, Fe-oxide spots.
6.10 – 6.58	Interbedding, middle sand and organic-rich layers, Fe-oxide bands, Tur-OSL-6 (6.43-6.58)
6.58 – 7.65	Greyish-brown fine to middle sand, non-bedded, fine-distributed plant remains, Fe-oxide spots, massive cryostructure
7.65 – 9.13	Greyish, fine sand, middle sand, weakly bedded, small plant remains, spotty
9.13 – 9.79	Fine sand, middle sand layers, organic-rich inclusions, brown-spotty, Tur-OSL-7 (9.66-9.79)
9.79 -10.34	Light greyish-brown, medium sand, fine sand, mica-bearing, brown-spotted, single thin organic-rich layers, 2 mm ice band
10.34 – 10.77	Greyish fine sand, brownish medium sand, weakly bedded, without plant remains
10.77 – 11.43	Greyish fine sand, brownish medium sand, weakly bedded, black coal-like inclusions

4.5.1.3 Exposure T021 (73.00°N, 123.830°E)

An additional exposure was dug into the terrace of the 2nd thermokarst lake on Turakh Island in order to continue the study of Arga-Complex deposits (see chapter 4.2). This profile exposes about 2 m of different sand layers (Figure 4.5.1.-4).

The permafrost boundary is located 1.25 m below the surface. The lowermost grey, frozen sands (samples T021-9 to –11, gravimetric ice content 15 to 20 wt%) are characterized by orange-brown coloured crack-like structures, which are lattice-like oriented. This lattice-like structure is similar to the one described in the exposures Tur-1 (chapter 4.5.1.1) and Ebe-4 (chapter 4.5.2.1) and typical of the "Arga-type" ice wedges. Above the permafrost boundary, a bedded sand with grey to orange colour alternations occurred (sample T021-8). This layer is covered by 25 cm thick sand with dark-brown iron-oxide schlieres (samplesT021-7 and –6). In 0.50 to 0.75 m depth a layer with horizontal, orange-brown bands was visible (samples T021-5 and –4). Higher between 0.25 to 0.5 m depth the well-bedded sand contains more organic and was spotty orange to grey coloured (sample T021-3). The uppermost part of the profile consists of grey and light-yellowish sand with roots (samples T021-2 to –0). Finally, a about 0.5 m thick layer of dune sand was accumulated at the surface.

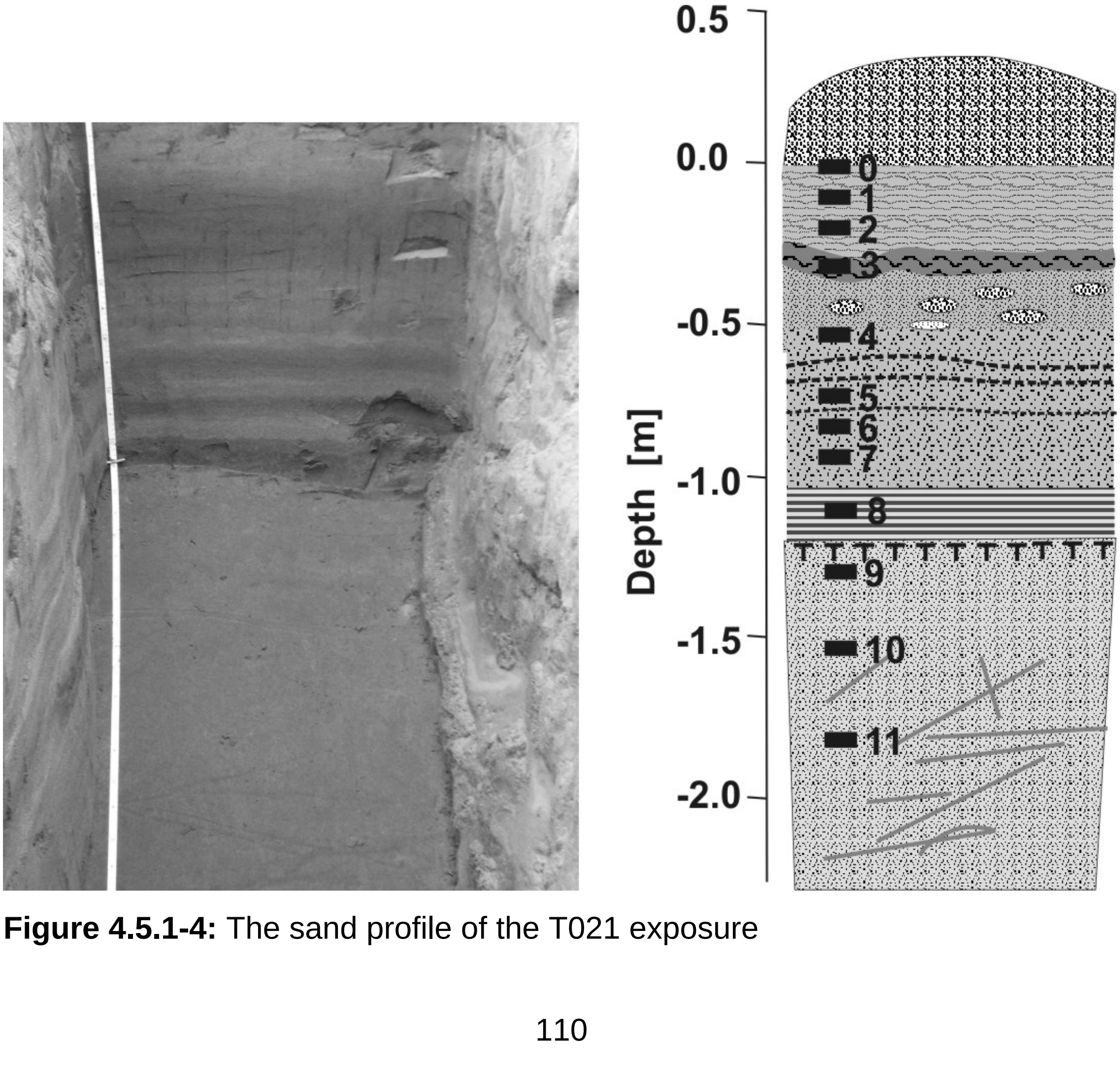


Figure 4.5.1-4: The sand profile of the T021 exposure

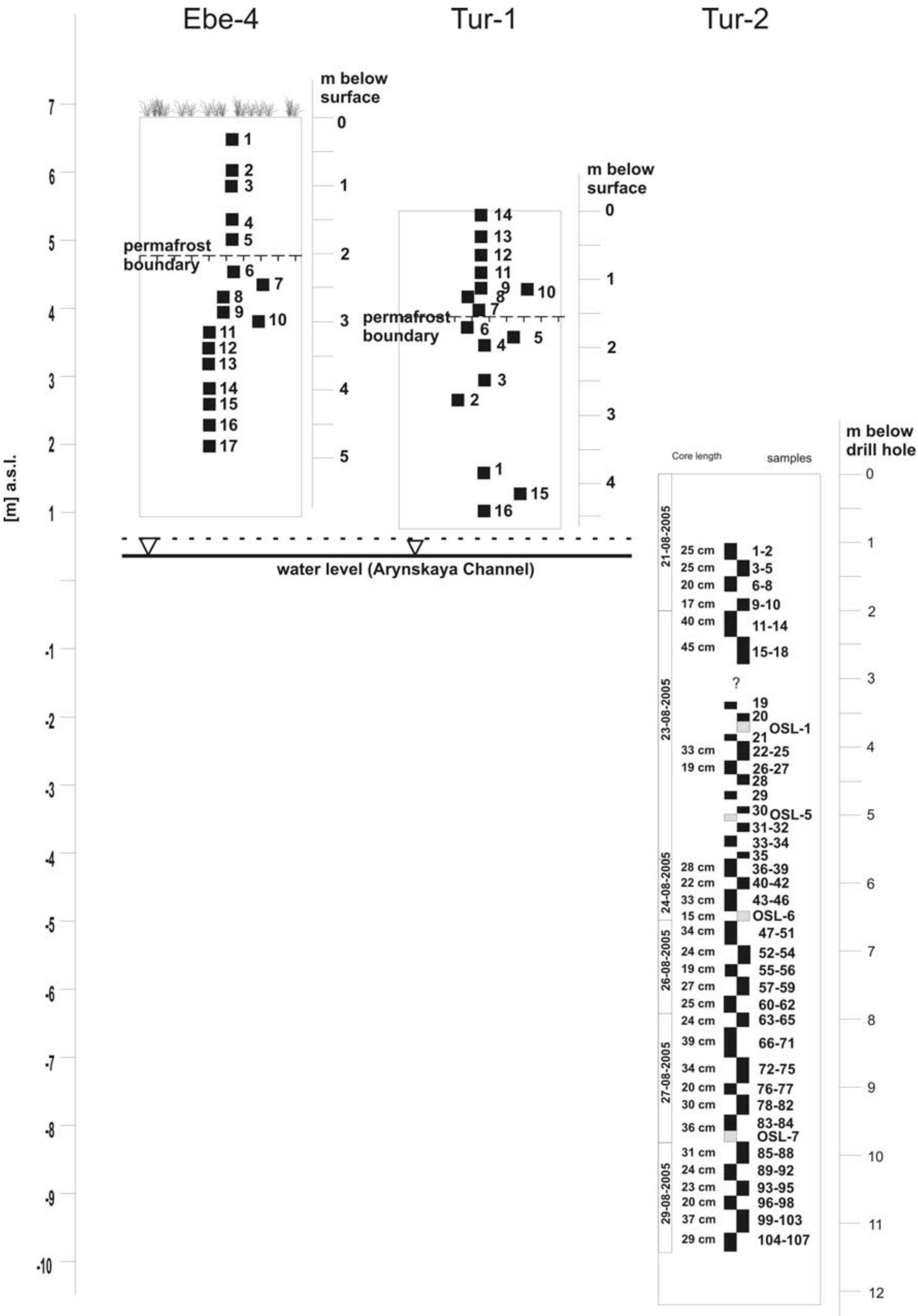


Figure 4.5.1-5: Correlation of the profiles Tur-1, Tur-2 and Ebe-4 based on tachymeter surveys

Figure 4.5.1-6: Exposure locations at Turakh Island and Ebe –Sise Island

4.5.2 Sand sequences of Ebe Basyn Sise Island

Lutz Schirrmeister, Mikhael Grigoriev, Tatyana Kuznetsova

4.5.2.1 Exposure Ebe-4 (72.965°N, 123.807°E)

A second large outcrop was dug just next to the camp site into the left bank of the Arynskaya Channel. The outcrop was dug in a 7 m high cliff, made of sands from the “Arga Complex” (Figure 4.5.2-1). The profile itself was about 5 m long. Only the lowest 3 m were frozen.

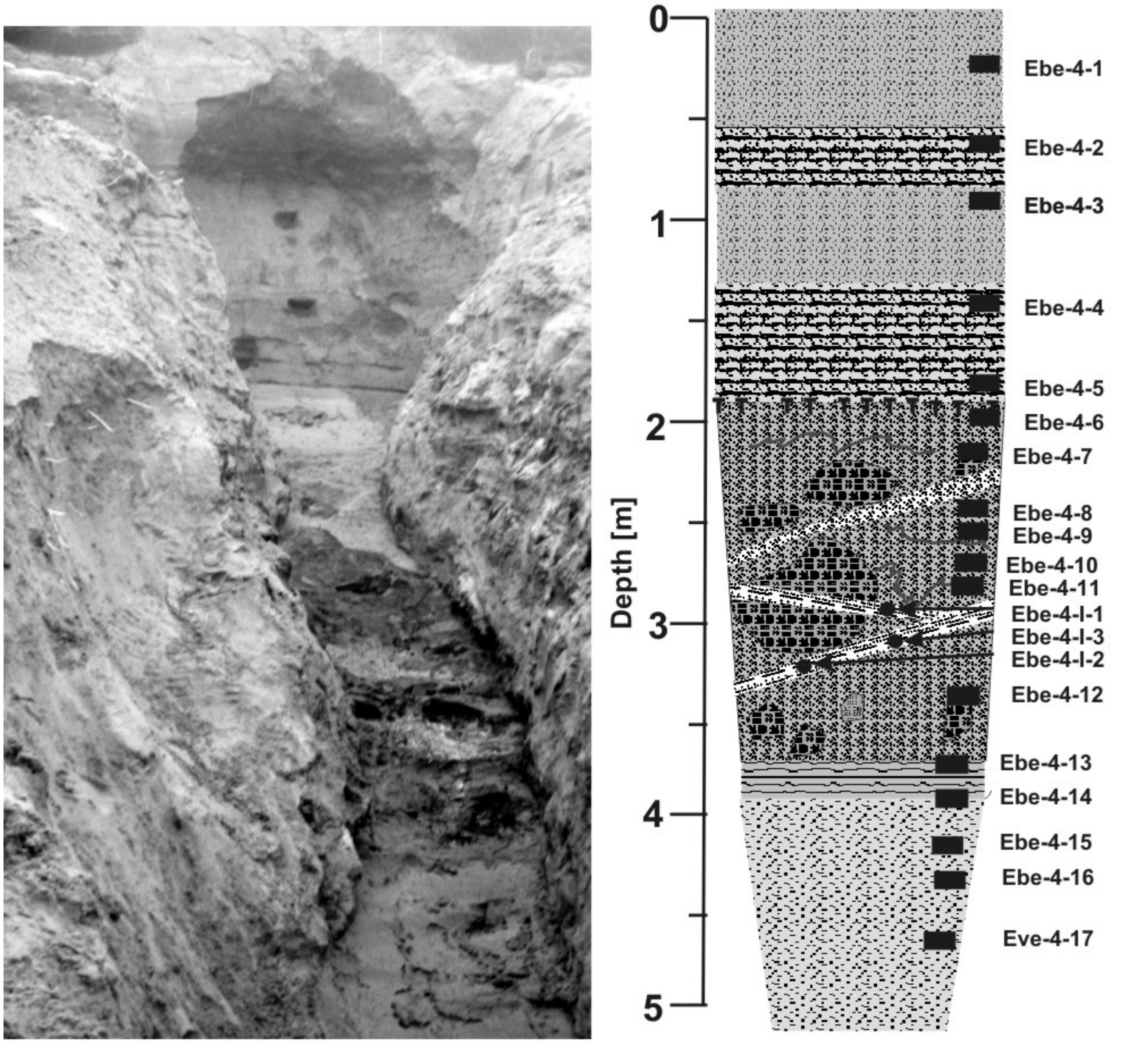


Figure 4.5.2-1: The sandy sequence of exposure Ebe-4 below the camp site

Between 5 to 4 m depths, spotty, yellowish-grey to brownish sand occurred without any visible sediment structure or cryostructure (samples Ebe-4-17 to 4-13; ice content 20-24 wt%). Between 4.00 to 3.50 m depth, angular, dark-brown, frozen peat fragments are incorporated into sandy frozen sediments (sample Ebe-4-12). It could possibly be a reworked fossil-horizon or refrozen peat material that was accumulated into a wave-cut notch in the banks of the Arynskaya Channel. Between 3.50 and 2.00 m depth level more peat inclusions were visible within frozen, yellowish sand (samples Ebe-4-11 to 4-6) but these inclusions are not as angular as below. This peaty-sandy layer featured two and 5 cm wide stripy ice-sand veins (samples Ebe-4-I-1 to 4-I-3) at 3.20 to 3.35 m depth as well as a sand-filled frost crack at 2.60 m. In addition, two horizons showing signs of cryoturbation structures occurred at 2.20 and 3.00 m depth. Two soil horizons of about 1 m thickness were observed above the permafrost table at 2.00 m depth. Each of this soil was characterised by a lower part featuring distinct bands (Figure 4.5.2-1).

4.5.2.2 Exposure Ebe-2 (72.929°N, 123.608°E)

In order to investigate the lateral contact between sandy deposits of the “Arga Complex” type and the well known Ice Complex sequences of Ebe Basyn Sise Island, several trips were undertaken further to the south of Ebe Basyn Sise Island, on August 19 and August 31. Unfortunately no evidence of a contact between these two deposits nor any indication of the existence of Ice Complex deposits (such as thermokarst mounds) were found during these trips, although those were took place up to 10 km southwest of the camp. Nevertheless, the investigated exposures will be used for paleo-environmental reconstruction and therefore have to be presented in this report.

The exposure Ebe-2 was dug on the western slope of a hill, which was at first thought to be a Yedoma-topographic high. The hole dug in the ground exposed an about 1 m deep sedimentary profile The lower part of the profile was frozen and featured an horizon of greyish fine-grained sand (samples Ebe-2-1, 2-2; ice content ca. 19 wt%). Within this horizon a 5 cm thick ice layer of unknown origin was also observed (Figure 4.5.2-2). The ice features parallel striped horizontal structures as well as vertical needle-like crystals (samples Ebe-2-I-1 to 2-I-4). Above the permafrost table we observed a 15 cm thick layer of unfrozen well-bedded grey sand (sample Ebe-2-3) and a brownish-grey, non-bedded, silty fine-sand that contained vertical grass roots (sample Ebe-2-4). Further up a 25 cm thick rooted and cryoturbated brownish soil horizon (sample Ebe-2-5, 2-6) contained a lot of plant remains. Finally the top of the profile exposed a 5 cm thick, grey and dry fine-sand layer of probably eolian origin.

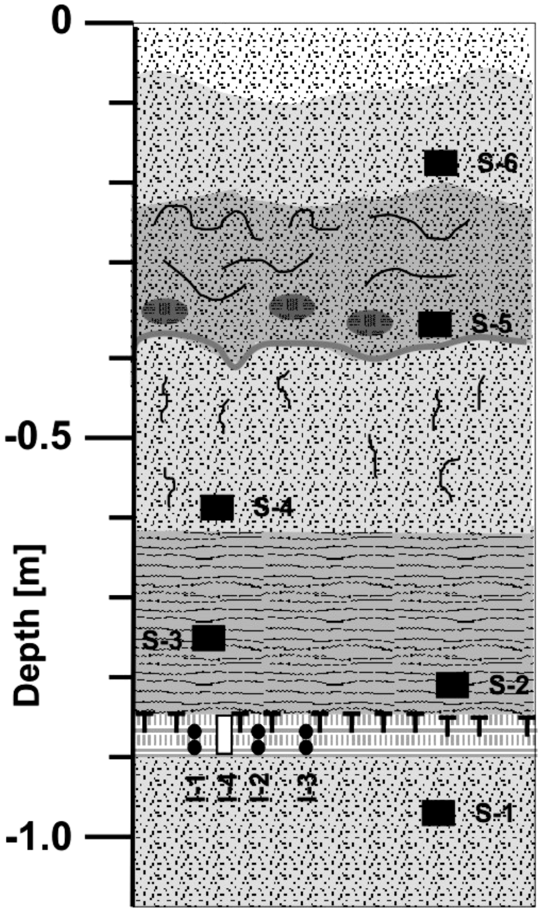
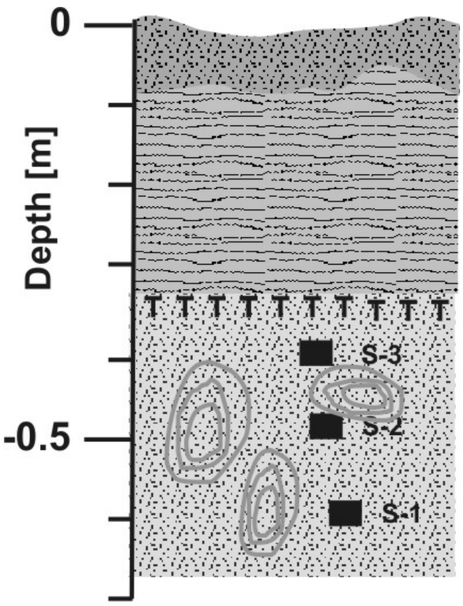


Figure 4.5.2-2: Exposure Ebe-2; Sandy soil sequence with segregation ice layer bear the permafrost table

4.5.2.4 Exposure Ebe-3 (72.927°N, 123.608°E)



The 60 cm deep profile Ebe-3 (Figure 4.5.2-3) was dug in the same area into a hill slope to the east of a thermokarst lake. The small hole exposed frozen greyish-brown fine sand with concentric rings of iron oxide impregnation between 30 and 60 cm depth (samples Ebe-3-1 to 3-3, ice content 25-30 wt%). Above the permafrost table unfrozen, greyish fine sand, containing small brownish bands and a cryoturbated brown horizon forms the modern soil layer.

Figure 4.5.2-3: The exposure Ebe-3

4.5.2.4 Exposure Ebe-5 (72.92 °N, 123.68 °E)

On the right bank of a small channel flowing parallel to the Utyan Uyesya Channel, an about 6 m high cliff was studied by T. Kuznetsova and V. Kunitsky on August 31. Two subprofiles were dug, which exposed the similar sandy sequence of frozen and unfrozen sands with lattice-like ice structures (Figure 4.5.2-4) mentioned in section 4.5.1. Undulate-bedded, fine to middle-grained, grey and frozen sand was exposed 3 m above water level (samples Ebe-5-1, 5-2). Just below the permafrost table a 5 cm thin ice vein was visible (sample Ebe-5-I-19), and was connected on the left hand side of the profile with a 30 cm wide ice wedge (sample Ebe-5-I-2). The horizontal ice vein was horizontally striped and contained a lot of gas bubbles. Unfrozen, well-bedded fine to middle grained sand occurred above the permafrost table, and was sampled up to 5 m above water level (samples Ebe-5-3 to 5-6).

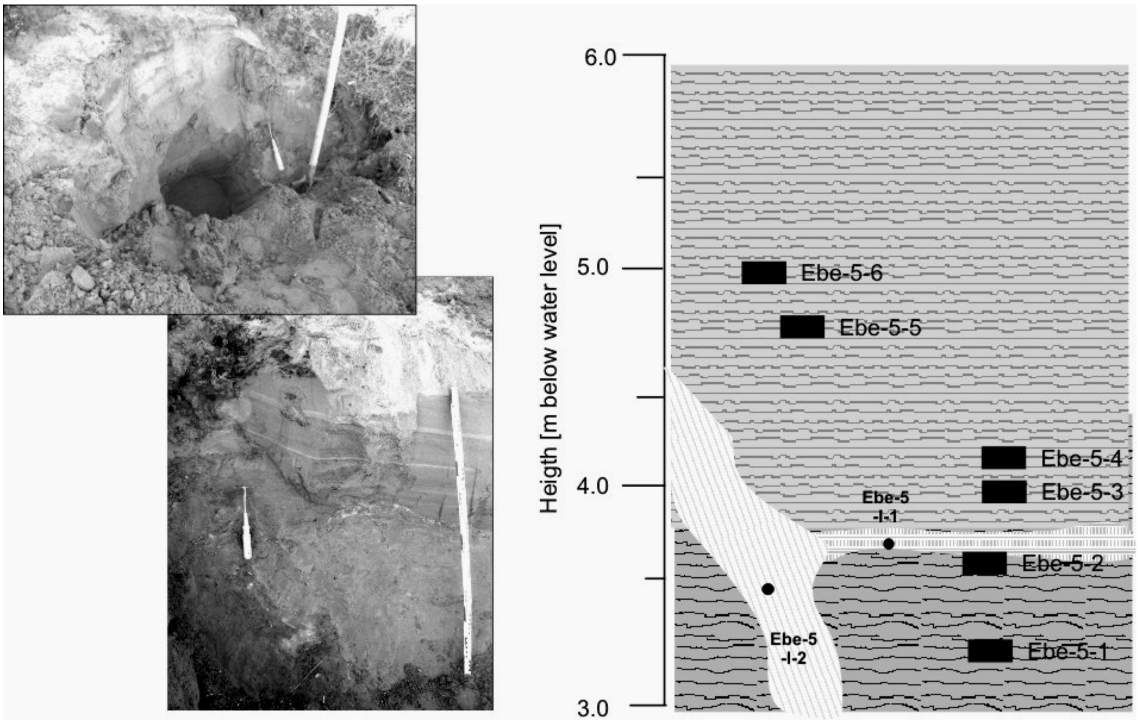


Figure 4.5.2-4: The combined profile of the Ebe-5 exposure

4.5.3 Sand and Ice Complex sequences of Khardang Island

Lutz Schirrmeister, Viktor Kunitsky, Tatyana Kuznetsova, Guido Grosse

As mentioned in chapter 4.5.2, the stratigraphic relation between the so-called "Arga-sands" of the 2nd terrace and the sandy units that underlain the Ice Complex deposits (3rd terrace) is still unknown. For this reason, a permafrost sequence located on the northwest coast of Khardang Island (3rd terrace, Figure 4.1-2, Figure 4.5.3-2) was studied. The site was reached by motorboat trips between August 25 and 30. For practical reasons, the investigation of the stratigraphic column between the beach level and the 20 m high top surface of the island was subdivided in several sub profiles exposed in thermokarst mounds (Baydzherakhs).

In general, the permafrost sequence consists of four different units (from bottom to top): 1) the lower sand unit up to 5 m height, 2) a 1 to 2 m thick peat horizon, 3) a peaty sandy transition zone (about 1.5 m thick) and 4) the Ice Complex unit (Figure 4.5.3-1).

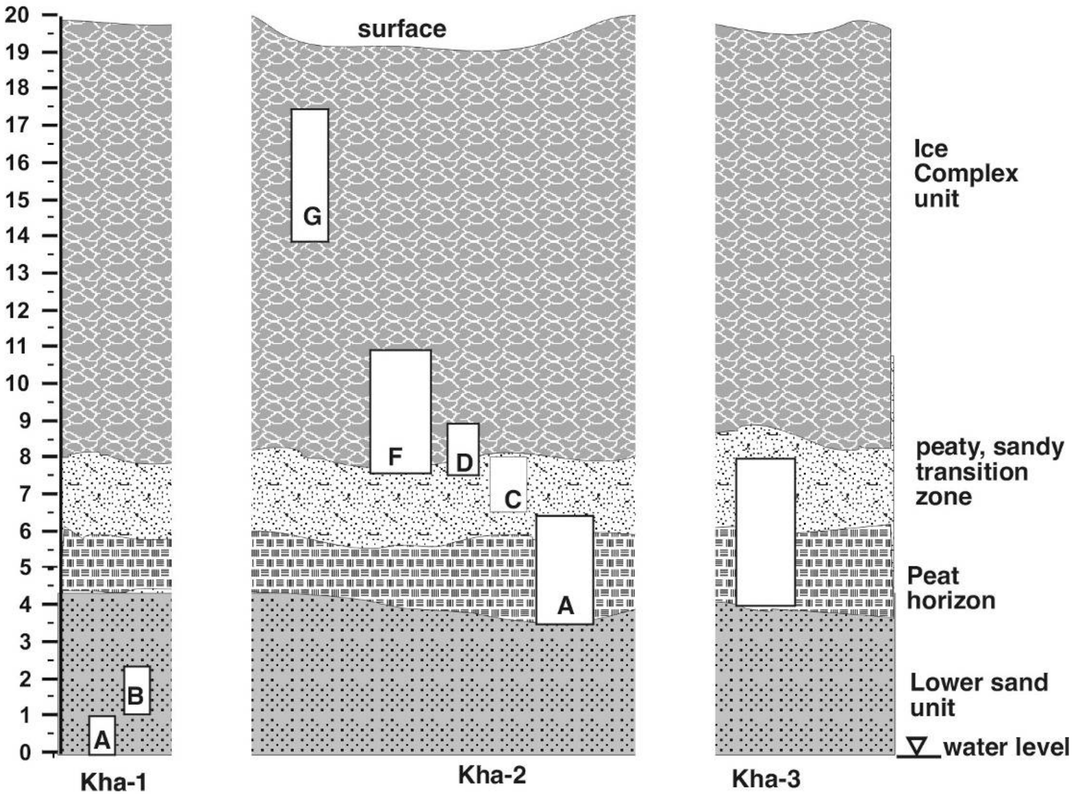
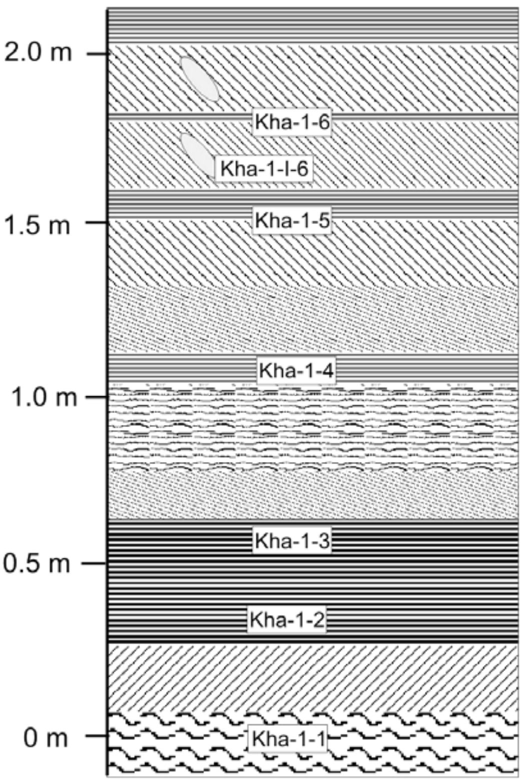


Figure 4.5.3-1: Schematic overview of the studied cliff sequence on Khardang Island and the position of the subprofiles

Figure 4.5.3-2: The studied cliff section with thermokarst mounds in northwest Khardang Island

4.5.3.1 The sand deposits in the exposure Kha-1

The lower part of the cliff is mostly constituted of a mix of horizontally- laminated and cross bedded layers. The sediments are mostly middle to fine-grained frozen sands with silty interbeds. The exposed part of this sandy layer was estimated to be approximately 8 to 10 m thick. Two subprofiles were investigated in this unit between 0 and 2.5 m above water level (samples Kha-1-1 to 1-6, Figure 4.5.3-1). The gravimetric ice content is relatively low and amounts 24 to 32 weight %. Two samples were collected for luminescence dating at 2.5 m and 7 m heights above water level (Kha-OSL-1, Kha-OSL-1). We noted the occurrence of cracks filled with small ice crystals within the frozen sandy deposits (Figure 4.5.3-3, sample Kha-1-I-1)



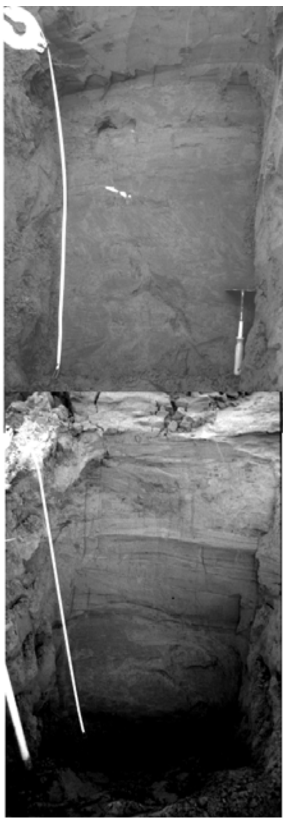


Figure 4.4.3-3: The sand profile Kha-1 near the beach level of the Arynskaya Channel

4.5.3.2 The sequence Kha-2

A peat horizon extends in about 5 to 7 m height above the river level along the studied cliff section. This horizon and the covering sediment were studied in several subprofiles of the exposure Kha-2 (Figure 4.5.3-4).

Figure 4.5.3-4: Thermokarst mound with Kha-2 subprofile exposures of the Arynskaya Channel cliff

At first sight, the peat horizon appeared to be continuous. However a closer look at the **Kha-2A** exposure revealed that its structure was far more complex The lowermost layer of 1.5 m thickness consists of peat fragments (clasts) within fine-laminated, greyish-green, fine-grained sand (samples Kha-2-1 to 2-4, gravimetric ice content 25 to 55 wt%). The next layer above is thin and sandier, and shows evidence of slumping structures (sample Kha-2-5, 2-6). A 0.5 m thick frozen moss-peat layer was observed further up (samples Kha-2-7 to 2-10, ice content 105 wt%). This layer probably reflects autochthonous accumulation conditions. The peat layer was additionally sampled at two heights for U/Th-dating (samples Kha-U/Th-1 to -5).

Overlying the peat is a greyish-brown cross-bedded sand (sample Kha-2-11). Further up, the strongly disturbed sediment structures probably indicate refrozen slump material. For this reason the upper part of the subprofile Kha-2A was not sampled.

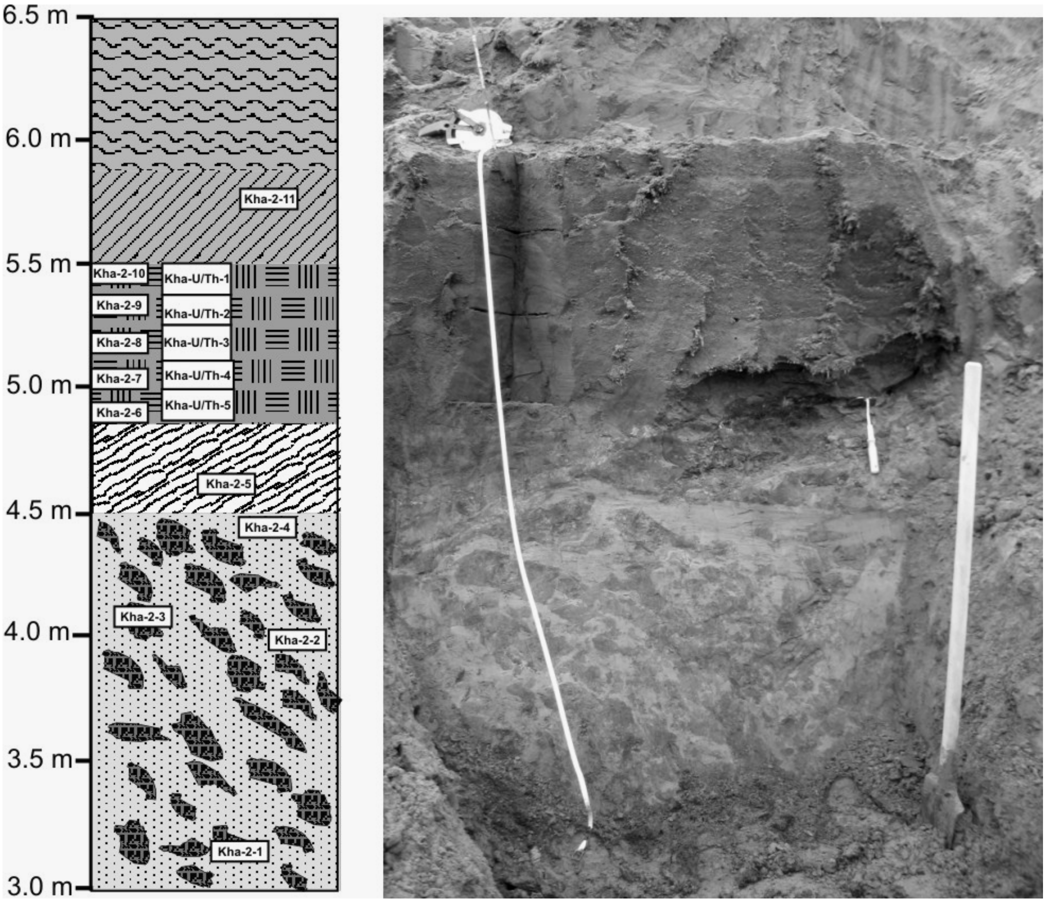


Figure 4.5.3-5: The subprofile Kha-2A (Khardang Island, Arynskaya Channel)

Between 6.6 and 7.5 m above water level, the subprofile **Kha-2C** (Figure 4.5.3-6) exposed thin (5-15 cm wide), lattice-like intersecting ice wedges (samples Kha-2-I-1 to I-4), and similar to those that were observed within the “Arga-sands” (Figure 4.5.3-6). The ice wedges consist of parallel and alternating ice and sand bands (so-called polozatiks). A larger peat inclusion on the left hand side (sample Kha-2-13) was covered by greyish fine sand (samples Kha-2-12, 2-14) containing the ice wedges. Above the ice wedges, a yellowish-grey silty fine sand showed sloping parallel structures (Kha-2-15).

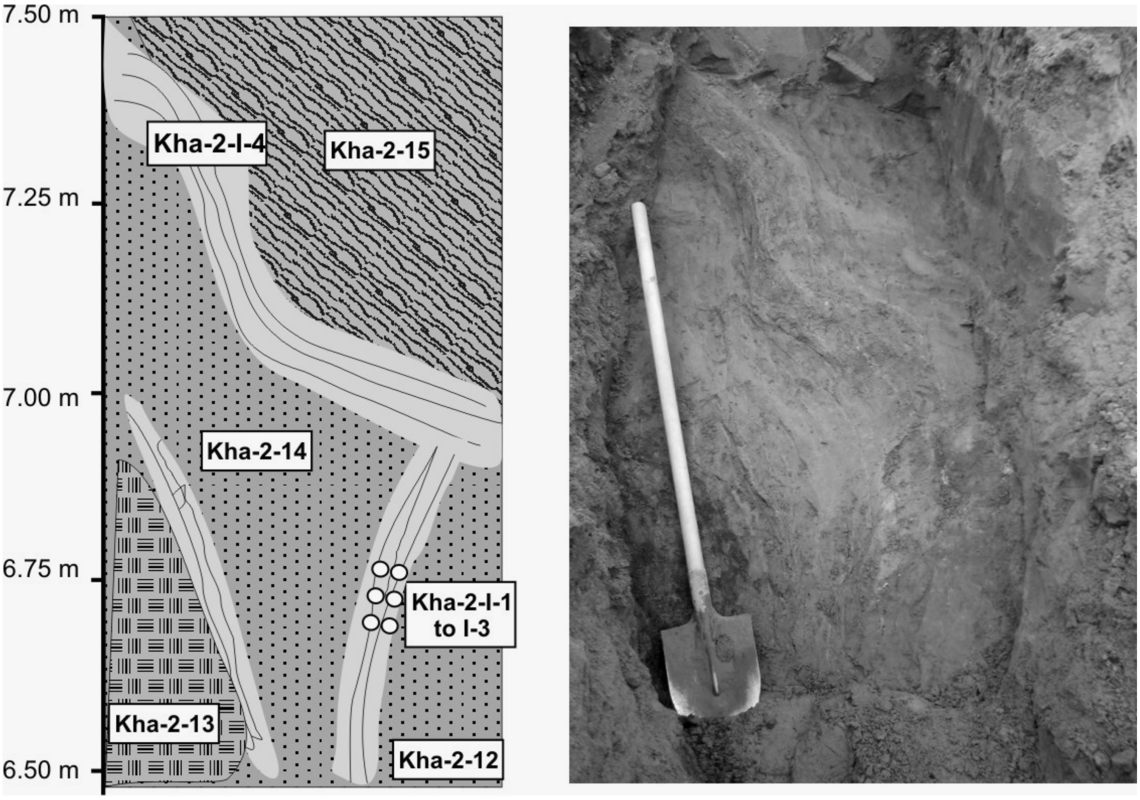


Figure 4.5.3-6: The subprofile Kha-2C, featuring a small ice wedge

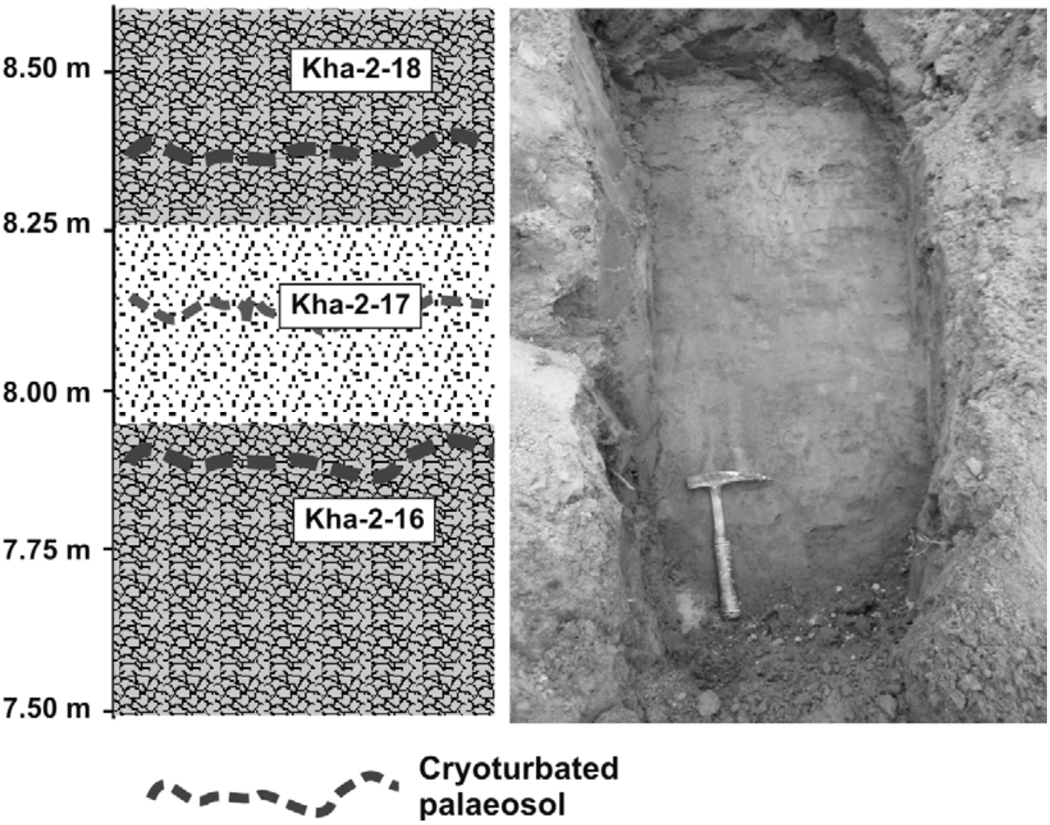


Figure 4.5.3-7: Ice Complex deposits of the subprofile Kha-2D

The next subprofile to the top **Kha-2D** (Figure 4.5.3-7) probably exposed the lower part of the Ice Complex sequence. This subprofile consists of two layers featuring ice-rich dark greyish-brown silty fine sand (aleurite) with banded cryostructures (samples Kha-2-16, Kha-2-18, gravimetric ice content 38 to 44 wt%), that alternate with greyish-brown sand with ripple-bedding (Kha-2-17, ice content 26 wt%). The layers contained weakly developed cryoturbated palaeosols.

Similar deposits were observed up to 11 m above water level. Ice-rich greyish sand (0.1-0.3 m thick) containing twig fragments, ice bands, and lens-like broken cryostructures are interbedded by light-grey to brownish sand layers (about 0.2 m thick). Huge ice wedges are typical in Ice Complex formation (Figures 4.5.3-2 and 4.5.3-4), but could not be excavated at this exposure. However the presence of thermokarst mounds indicates the existence of such ground ice bodies.

The subprofile **Kha-2F** (Figure 4.5.3-8) is a typical Ice Complex sequence and lies directly above the subprofile Kha-2C (Figure 4.5.3-1). The lower layer, featuring 0.2 m thick yellowish green sand (sample Kha-19) matches the upper part of the Kha-2C subprofile (sample Kha-2-15). Greyish ice-rich and organic-rich fine sand with lens-like reticulated and banded (0.5 to 5 cm thick) cryostructure occurred between 7.7 to 10 m above water-level (samples Kha-2-20 to 2-23, gravimetric ice content 47- 96 wt%). A cryoturbated palaeosol of about 0.5 m thickness with peat inclusions overlain the latter (sample Kha-2-24, ice content 23 wt%). Greyish ice-rich sediments similar to the ones mentioned above are found in the upper part of the sediment profile (samples Kha-2-24 to -27, gravimetric ice content 50 - 92 wt%).

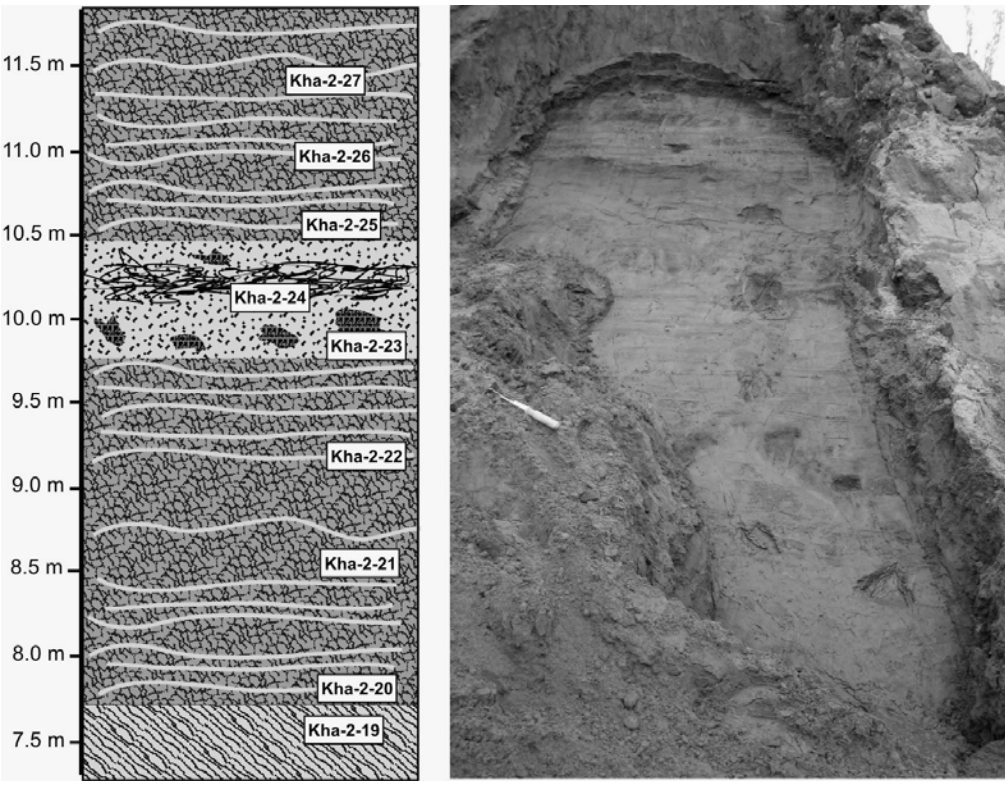


Figure 4.5.3-8: Ice Complex deposits at the subprofile Kha-2F

The uppermost subprofile, **Kha-2G,** consists of several alternations of ice-rich, ice-banded silty fine-sand layers. Several lens-like reticulated cryostructures and ice-poor palaeosol horizons with peat inclusions can also be observed (Figure 4.5.3-9). The gravimetric ice content ranged between 50 and 115 wt%.

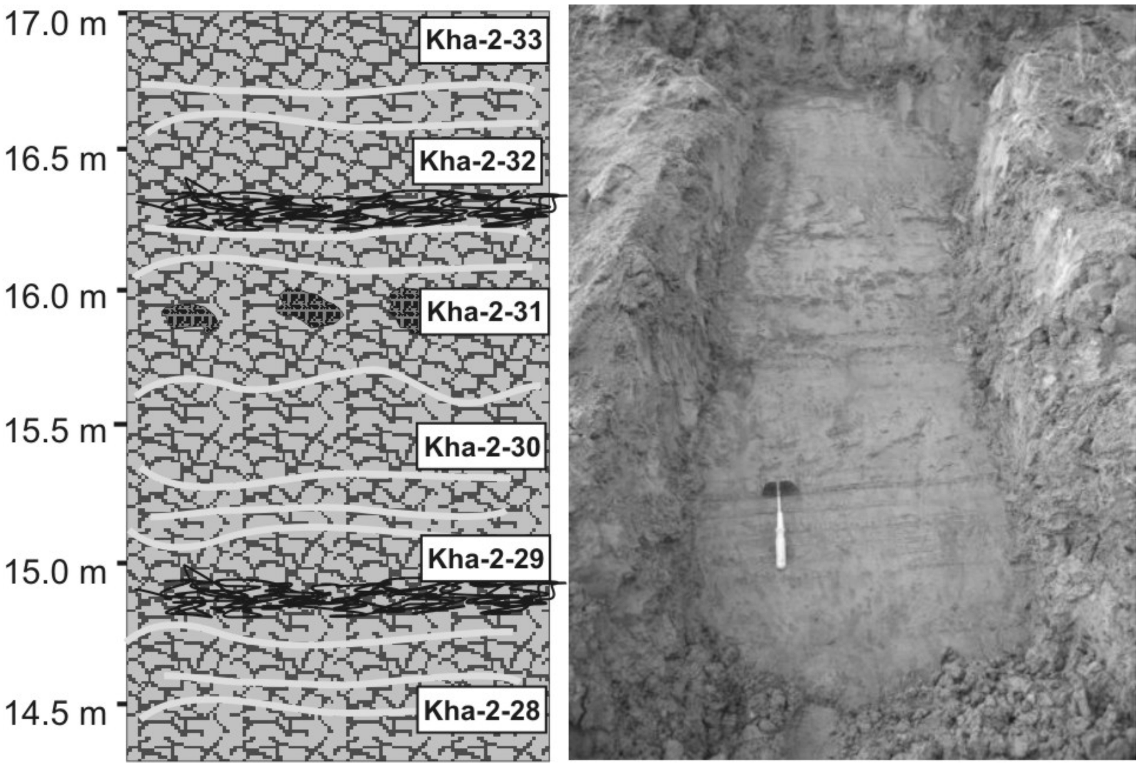


Figure 4.5.3-9: Ice-rich deposits of the uppermost subprofile Kha-2G

4.5.3.3 Exposure Kha-3: large ice wedge and surrounding sediments

A larger ice wedge was accessed within a small narrow thermoerosional valley (Ovrag) about 300 m north from the exposure Kha-2. The ice wedge was cleaned and sampled for isotope studies at different levels using ice screws and a small axe (samples Kha-3-I-1 to I-11). The ice wedge was exposed at the southern valley slope, and occurred within a sandy horizon (Figure 4.5.3-10). The lowermost part consists of yellowish-grey fine sand (sample Kha-3-1). Further up, the ice wedge traverses a peat layer (Kha-3-2, 3-3) similar to those of the subprofile Kha-2A. The higher part of the section is made of greyish, fine sand with numerous brownish and blackish spots together with small twig fragments (sample Kha-3-4). The actual ice wedge thickness amounts to about 0.5 m. Ice belts concavely bent towards the ice wedge reflect syncryogenetic ice wedge formation. The ice wedge is striped with alternating 0.5 to 2 cm wide sand and ice stripes (Figure 4.5.3.-11). Its volumetric sand content was visually estimated to be 40 %. Such striped sand-ice wedges are termed “Polozatic”.

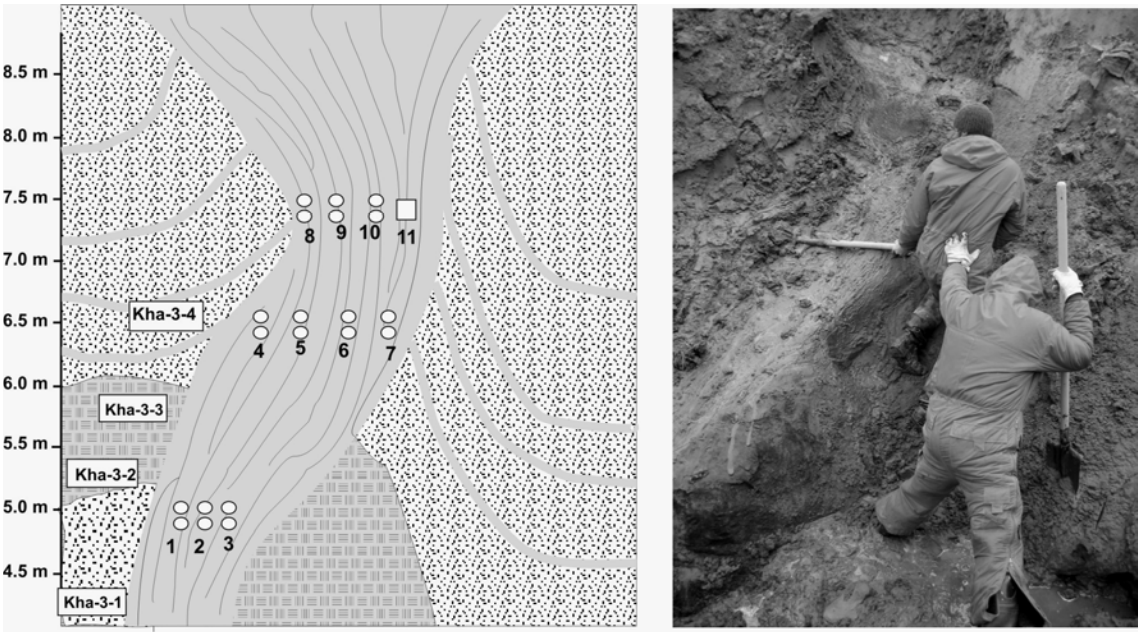


Figure 4.5.3-10: Ice wedge within peat and sand deposits at the Kha-3 exposure

Figure 4.5.3-11: Stripped ice structure (vertical silt-ice stripes) in the ice wedge Kha-3

4.6 Subsurficial and Bathymetrical Ground Penetrating Radar (GPR) Investigations

Hugues Lantuit and Waldemar Schneider

A series of Ground Penetrating Radar (GPR) transects were undertaken in order (1) to map subsurficial ground stratigraphical features in the vicinity of investigated exposures and/or boreholes and (2) to map the bathymetry of the Arynskaya Channel.

4.6.1 Subsurface mapping of the Arga sands stratigraphical unit

The Arga sands formation deposition was presumably associated with a “high accumulation rate implied by a fluvial environment under upper flow regime” (Schwamborn, 2002). As highlighted in previous studies (Schwamborn et al., 2000) it implies complex stratigraphical interpretations, associated with age inversions within the stratigraphical columns of cores extracted from the Arga sands (Krbetschek et al., 2000). The nature of sedimentary processes at the time of deposition can be partly deduced from the morphometric characteristics (i.e. height, width, inclination) of sub-units within the stratigraphical column. However, those can hardly be captured by borehole and exposure investigation which are either strictly limited to a pre-established instrumental width (e.g. the mean diameter of collected cores in section Tur-2 is 6 cm) or by the inconspicuous nature of surrounding slopes in exposures which are often covered with sloping degraded material from the upper sub-units. Schwamborn et al. (2000) showed that GPR transects, undertaken in the Arga sands formation could reveal the nature of sediment bedding in the upper decameters and thereafter provide a further insight into the nature of deposition processes. In return, if GPR transects are operated immediately above investigated boreholes/exposure, collected sedimentological investigations on core and/or exposures will yield crucial information to the calibration/validation of GPR results, namely medium permittivity and velocity values. Therefore, a series of GPR transects was undertaken in late summer 2005 to aid interpretation of the boreholes and exposures described in the chapters 4.5.1.1 and 4.5.2.1. The location of these transects is shown in figure 4.6-1.

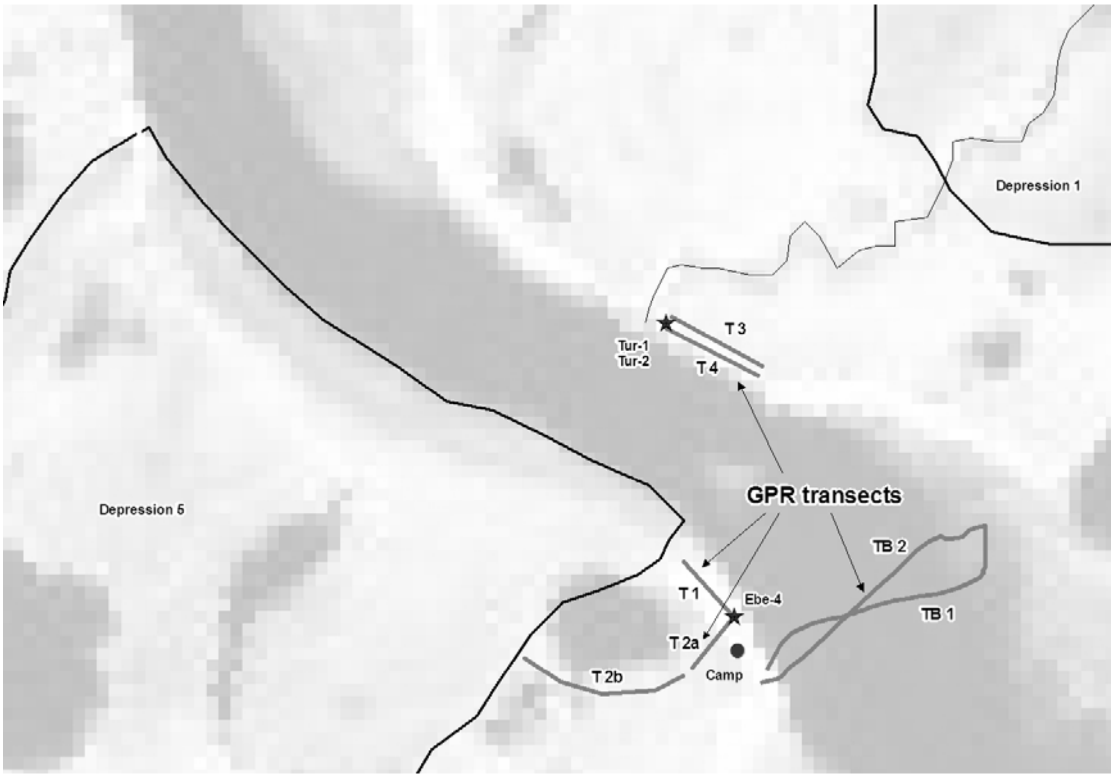


Figure 4.6-1: Distribution of transects on Ebe-Basyn-Sise and Turakh Sise Islands and location of corresponding exposures/boreholes investigated during the course of the Lena 2005 expedition.

4.6.1.1 GPR survey configuration

The impulse radar device used for the survey was a RAMAC/GPR System, which consists in integrated control unit, field PC and 50 and 200 MHz antenna units containing both transmitting and receiving antennas (Figure 4.6-.2). The control unit generates time cycles to switch on and off the transmission of impulses by the transmitter and synchronizes these sequences with the receiver. All operations were handled by the operator(s) in the field on a Husky PC equipped with the appropriate software. Each trace was manually collected by the operator(s) by pressing the “record” key. A pre-determined sampling length interval was used to translate these measurements into distances. However, due to the irregular topography of the tundra surface, and the subsequent modification of the operator’s pathway, we can assume the occurrence of small to large errors (i.e. up to 50% of the sampling length interval) during surveys. Therefore, distances between mark points (including start and end points) along the survey transect were measured in the field in order to correct for this error. The type of antenna (i.e. its frequency) as well as the general settings for data collection is described in the following sections for each transect. A summary of these settings is listed in table 4.6-1.

Table 4.6-1: GPR transects settings

Transect name	Antenna frequency (MHz)	Sampling frequency (MHz)	Time window (ns)	Number of stacks	Antenna separation (m)
T1	50	545	917	32	4.0
T2a	50	545	917	32	4.0
T2b	50	545	917	32	4.0
T3 (1)	50	552	906	32	4.0
T3 (2)	50	355	881	32	4.0
T4 (1)	50	401	998	64	4.0
T4 (2)	50	553	906	64	4.0
TB1	200	1173	551	16	0.6
TB2	200	1234	799	16	0.6

Figure 4.6-2: Set-up of the GPR system above exposure Tur-1. The antennas are towed behind the operator who carries the control unit and the PC unit.

4.6.1.2 Transects at exposure Ebe-4 (72.965°N, 123.807°E)

Two intersecting transects were surveyed at Ebe-4 with the 50 MHz antennas (see Figure 4.6-1). The intersecting point for the two transects was located just above the 6 m high exposure. Transect 1 was traced along the top of the shore cliff and Transect 2 roughly perpendicular to the Transect 2 landwards. Transect 2 was operated in two parts. The first part (Transect 2a) was kept straight and traces were recorded over a 120 m distance. The second part (Transect 2b) corresponds to the extension of Transect 2b landwards along a non-straight path. Transect 2b was meant to be acquired over two distinct morphological units, namely the shore of the river and the thermokarst depression (Alas) located about 500 m inland from the Ebe-4 exposure. The reader is referred to figure 4.6-1 for further explanation. Transect 1 was surveyed several times using different sampling settings (see Table 4.6-1) while Transect 2 was run one time using fixed settings. One of the resulting profiles is shown in figure 4.6-3

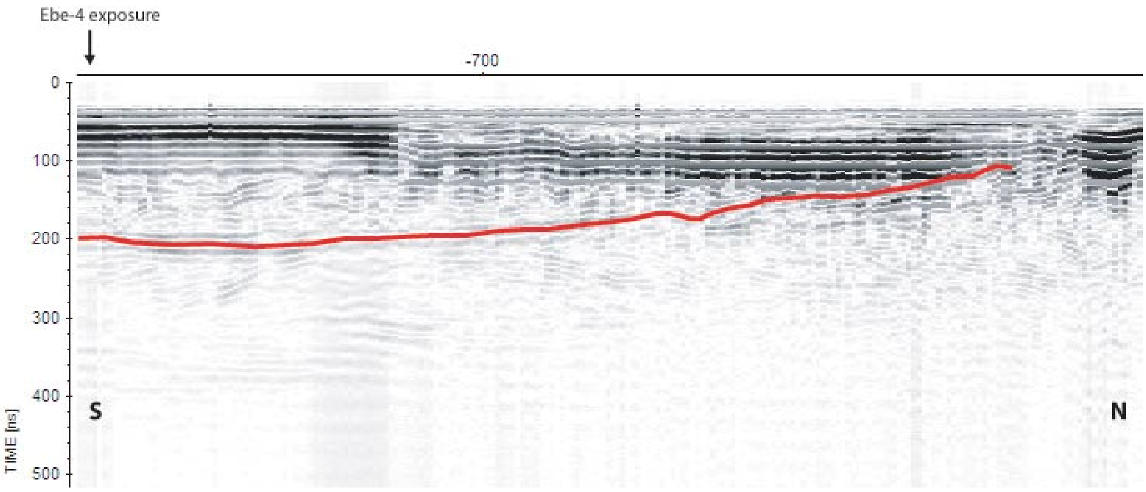


Figure 4.6-3: Close up on the southern section of transect 2a. Obvious stratigraphic interfaces are highlighted using solid lines

4.6.1.3 Transects at exposure/borehole Tur-1/Tur-2 (72.97408° N; 123.79858°E)

Two transects (3 & 4) were surveyed on the opposite side of the Arynskaya Channel, in order to correlate GPR measurements with stratigraphic information from Tur-1 and Tur-2. The two transects were performed using similar settings over two parallel transect lines. The first transect was undertaken at the top of the cliff overlooking the Arynskaya Channel, while the second transect was done on the narrow sandy strip at the foot of the cliff. Sampling settings are reported in table 4.6-1.

4.6.2 Arynskaya Channel bathymetry

The Arynskaya Channel is located in the western part of the Lena Delta. It is the second in importance in this part of the Delta after the Olenekskaya Channel. It begins at a confluent with the Olenekskaya Channel approximately 100km to the north-west of the delta apex. It then flows between Kyuryuelyakh-Sise Island and Khardang Island on the southern side and Turakh-Sise on the northern side until one branch merges with the Olenekskaya channel in the area of the Olenekskaya channel mouth (*Utya Uyesya Channel*) while the other branch bifurcates to the north, dissecting the Arga sand stratigraphic unit and finally forming a small estuary at its exit to the sea (Cape Cherkannakh-Tumsa). Its mean annual water discharge is believed to be small in relation to the other delta channels. It is thought to catch only a small part of the mean annual water discharge of the Olenekskaya Channel, which represents itself only 6.8% of the total mean annual water discharge of the Lena Delta (Pavlova and Dorozhkina, 2000). Thus, relatively to the other channels in the Lena Delta, the Arynskaya Channel is poorly studied because of its presumed low significance in the hydrologic system and sediment budget of the Lena Delta (Rachold et al., 2000). There is actually no current high resolution source of information on the channel's bathymetry (D. Bolshiyanov, personal communication, 4.9.2005).

Further knowledge on the Arynskaya Channel's morphometric characteristics is however necessary to the understanding of the Arga sand complex, since it is the only channel of importance to dissect this stratigraphical unit. The time of installation of the Arynskaya Channel in its current bed that is through the Arga sand complex, is largely speculated and a precise assessment of its morphometry can serve several purpose, including the reconstruction of its chronology. While subaerial morphometric characteristics can be drawn from air- or space-borne imagery, its bathymetry must be recorded in the field.

A GPR survey was therefore run to map the channel´s bottom surface across the western-most branch of the Arynskaya Channel. For technical details on the RAMAC GPR unit the reader is referred to section 4.6.1.1. An experimental survey configuration was installed in a small rubber boat (2,5m x 1m) towed behind a motorized "zodiac"-type boat (Figure 4.6-4).

Figure 4.6-4: experimental setup of the GPR antennas in a rubber boat towed behind a motorized boat.

The configuration consisted of a pair of 200 MHz antennas mounted in the boat with the axis transmitter-receiver parallel to the boat direction. The operator was installed in the small rubber boat in order to provide sufficient weight against potential wave action and to proceed to manual recordings of pulse traces. The position of the boat across the channel was permanently monitored from the shore by triangulation and additional points were acquired from the motorized rubber boat by echosounding (see chapter 4.3 for technical details on echosounding bathymetry) to provide a source of calibration/validation for the GPR profile. Two transects were successfully surveyed across the branch and are shown on figure 4.6-1

Correction/validation of the GPR datasets was done using typical values for water relative permittivity and velocity. Two different sets of sampling parameters were used for the two transects and are listed in table 4.6-1. One of the resulting 2D profiles is shown in figure 4.6-5. The bottom floor is easily identifiable on the filtered profile. It reaches a maximum depth of approximately 5.6 m and is characterized by three main morphological elements:

1. A very shallow (< 1.0 m) and flat zone located next to the shore and featuring a secondary reflector located approximately 0.5 m below the channel bottom floor, 2. a zone characterized by depths ranging between 1.0 and 4.0 m with a fairly inhomogeneous topography and 3. a narrow and deep (5.6 m) zone surrounded by steep underwater levees (~ 2.0 m deep).

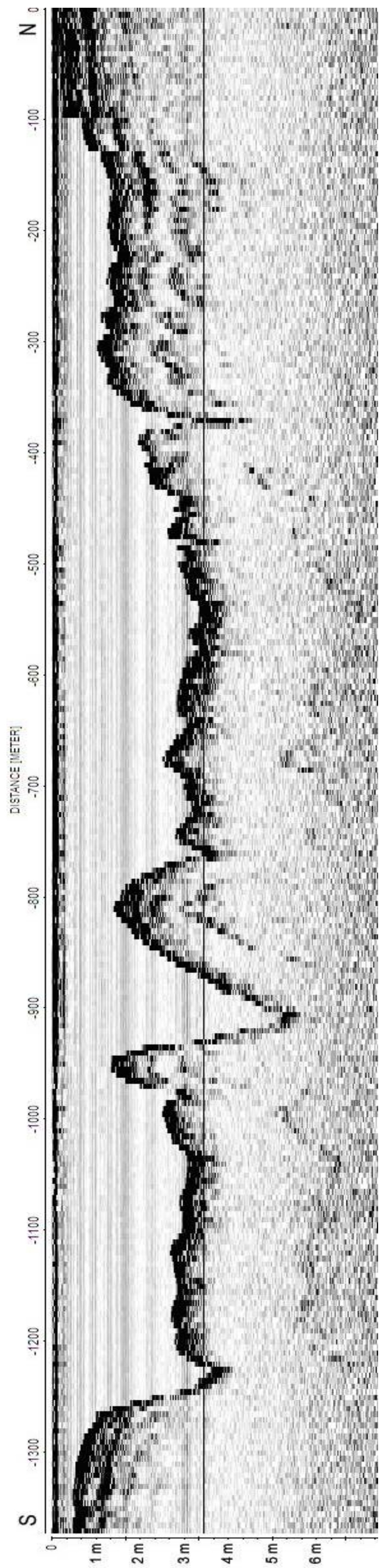


Figure 4.6-5: S-N bathymetric profile (TB2) of the Arynskaya Channel. Depths marked in meters are calculated using a 0.033 m/ns velocity for water.

4.7 Measuring of local weather and soil conditions by soil probe and weather station

Guido Grosse and Lutz Schirrmeister

During the field season almost continuous loggings of soil temperature and soil moisture were conducted with a soil probe at sandy site in the vicinity of the camp at Ebe-Sise Island. The main vegetation consisted of grass, and the soil surface was slightly tussocky. The soil probe sensors were fixed in 5 cm depth. The measurement interval was 5 min. The logging lasted from 22nd August to 31st August 2005. The breaks in the logging period are caused by failure of power supply for the probe. Table 4.7-1 shows the extreme values during the logging. Whereas the temperature shows diurnal variation and a slight decrease during the whole period (Figure 4.7-1), the logging of volumetric soil moisture showed an almost constant moisture content of 0.4 m3 x m-3 in the upper soil during the measurement period without diurnal variation.

Table 4.7-1: Values for in situ soil temperature and soil moisture (measured as electric soil voltage) logged with a soil probe in the upper 5 cm of a sandy site near the camp

	Min	Max	Mean	Sd (+/-)	Logged values
Soil temperature	0.38 °C (24-08-04)	7.94 °C (13-08-04)	3.31 °C	1.88	1978
Volumetric soil moisture	0.14 m^3 x m^{-3}	0.32 m^3 x m^{-3}	0.24 m^3 x m^{-3}	0.03	1978

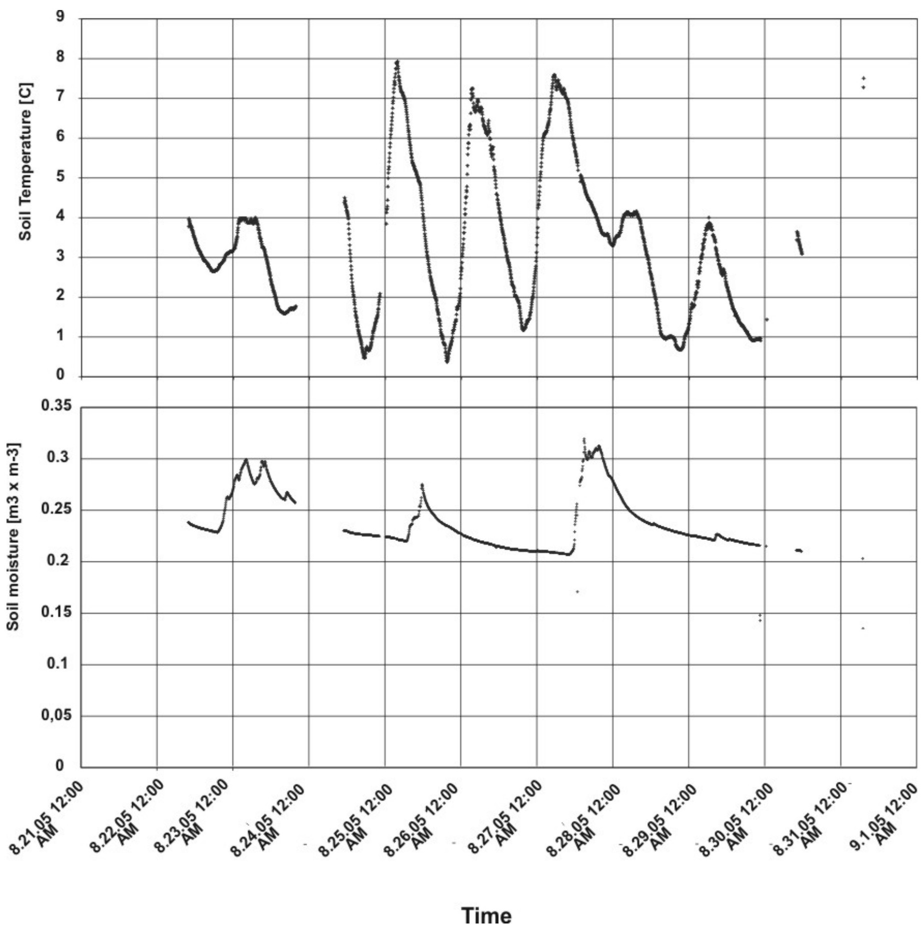


Figure 4.7-1: Diurnal variations in soil temperature within the upper 5 cm of an Edoma surface

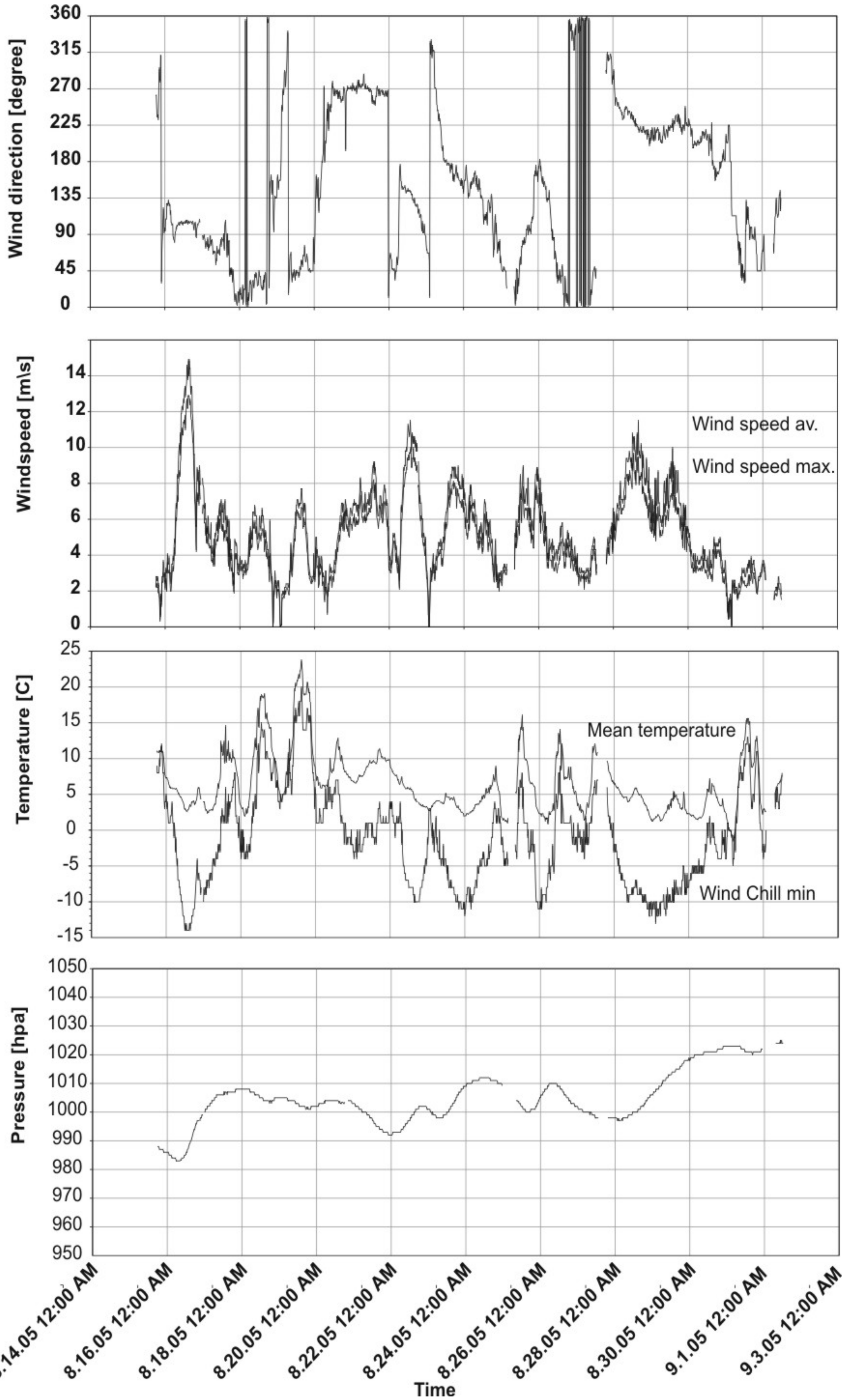


Figure 4.7-2: Weather data of the expedition period on Ebe Sise Island

At the same place a small climate station was installed measuring wind orientation, wind speed, air temperature in 2 m height above surface as well as air pressure, wind chill temperature between 16th August and 1st September (Figure 4.7-2, 4.7-3).

Figure 4.7-3: Measuring site for soil probe and climate station near the camp.

4.8 Paleontological collection of the "Mammoth" fauna from the museum of the Lena Delta Reserve

Tatyana Kuznetsova

Remains of large Pleistocene mammals always attract attention. Scientists and local people who work and live in the Laptev Sea Region find and collect various bones and fragments of large mammals. Some of them are brought to the Lena Delta Reserve. Mammal remains of the "Mammoth fauna" are the most common artifacts in the paleontological collection of the Lena Delta Reserve museum. The collection includes single bones, fragments of skeletons, bones with soft tissues and hair of Late Pleistocene and Holocene specimens. It consists of nearly 300 samples.

The museum was created thanks to the enthusiasm of Dr. A. Gukov, the present director of the reserve. Employees of the reserve, school teachers, pupils and other interested people also contribute. The first specimens were collected in 1985. They were bison bones collected by Yarlykov Yu. A. on Makar Island (Yana Delta Region) near the Makar polar station; Efimov S. N. found horse and reindeer bones on the Myostakh Cape, Bykovsky Peninsula (Lena Delta Region). Mammoth and reindeer bones were collected by Gukov A. Yu. during the same year on Kurungnakh-Sise Island (Table appendix 4-6, Figure 4.8-2).

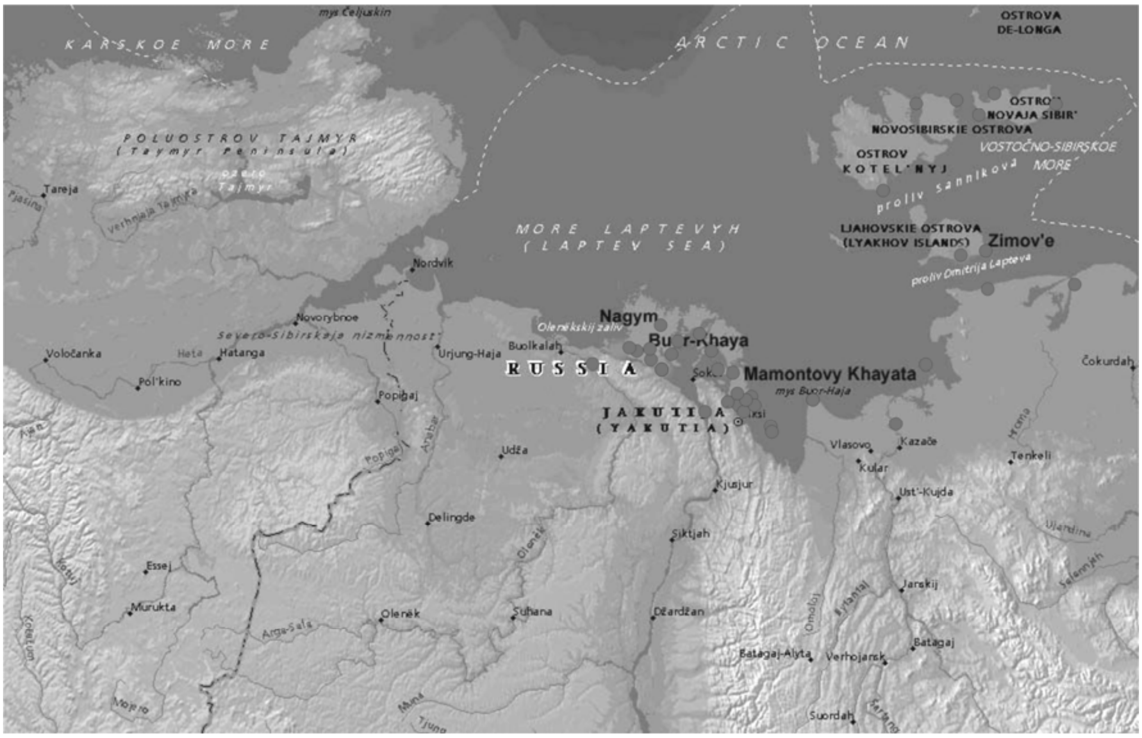


Figure 4.8-1: Collecting areas of the paleontological collection of the Lena Delta Reserve museum

Over more than 20 years many people have presented their finds to the reserve. These are samples from different islands of the Lena Delta Region, from the New Siberian Islands, from the Yana Delta Region, and from the southern coasts of the Laptev and East Siberian Seas (Figure 4.8-1). Most of the collection consists of bones from the Bykovsky Peninsula (about 100 samples) as well as from the islands of the Lena Delta Region. Unfortunately not all samples have exact information about their origins nor is geological information available for all finds. It is typical for this exhibition that the finds were collected by amateurs (not during geological or paleontological expeditions).

A considerable portion of the collection consists of finds of Dr. A. Gukov from different locations within the Lena Delta Reserve. In 2001 Dr. A. Sher delivered about 40 samples from the Bykovsky Peninsula (Mamontovy Khayata) to the museum (Table appendix 4-6).

Table 4.8-1: List of taxa of the paleontological collection of the “Mammoth” fauna from the museum of the Lena Delta Reservation.

Class MAMMALIA – mammals

Order Proboscidea

Mammuthus primigenius (Blum). – woolly mammoth

Order Artiodactyla

Family Cervidae

Rangifer tarandus (L.) – reindeer

Cervus elaphus L. – red deer

Family Bovidae

Bison priscus (Boj.) – Pleistocene bison

Ovibos moschatus Zimm. – muskox

Order Perissodactyla

Family Equidae

Equus sp. – horse

Family Rhinoceratidae

Coelodonta antiquitatis (Blum.) – woolly rhinoceros

Order Carnivora

Family Felidae

Panthera spelaea (Gold.) – cave “lion”

Family Ursidae

Ursus arctos L. – brown bear

Near half of the collection (49.8%) are woolly mammoth bones usually leg bones (Figure 4.8-3), which is typical for an unspecialized collection. Remains of bison, horse and reindeer form 20.4%, 16.3% and 9.3%, respectively. 2.4% of the samples come from musk oxen (Figure 4.8-2). The collection has single specimens of woolly rhinoceros, caver “lion”, bear and red deer (Table appendix 4-6. Table 4.8-1).

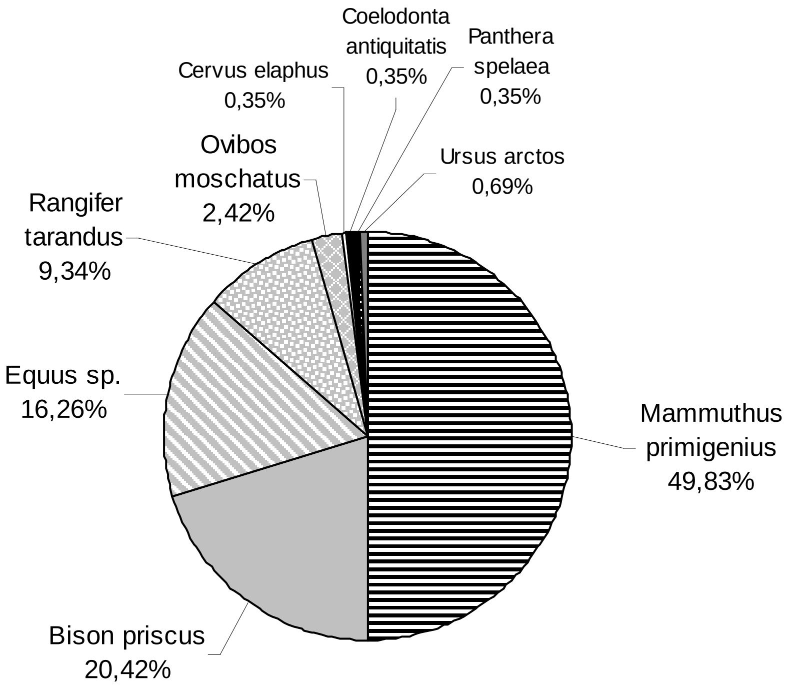


Figure 4.8-2: Composition of paleontological collection of museum of Lena Delta Reservation (total number - 292 specimens)

The museum collection contains rare and interesting samples.. Several bones of woolly mammoth had some well-preserved soft tissue (ligaments) and bone marrow inside them. There are two unique specimens – the skull and lower jar of a small mammoth and a fragment of the lower jaw of a baby mammoth. A damaged skull and lower jaw of a small woolly mammoth (LDR – O14-O15) were found S. Yu. Volkov in 2002 on Kurungnakh-Sise Island, Buor-Khaya (Lena Delta Region). The skull was restored from fragments and includes two teeth and small tusks. The fragment of the lower jaw of the baby mammoth (LDR – O50) has two milk teeth, which had not yet emerged. This specimen was very well preserved.

Figure 4.8-3: Different bones of *Mammuthus primigenius* from the Lena Delta Reserve museum collection.

Figure 4.8-4: Skull fragment of *Bison priscus* (LDR-O 271). It was found by N. V. Gukova on the Muostakh Cape, Bykovsky Peninsula (Lena Delta Region) in 2001.

Figure 4.8-5: Skull of *Equus sp*., very well-preserved (LDR-O 19), collected by A. Yakshina on the Rozhina Cape (New Siberian Island) in 2000.

Figure 4.8-6: Skull of male of *Ovibos moschatus*, very well-preserved (LDR-O 228). presented by S. E.Krasovskiy (Taimylyr village), in 1988.

The museum's paleontological collection includes animal hair as well (Table appendix 4-6). There are several specimens of woolly mammoth hair of different colours and lengths. I. A. Yakshina, F. V. Sellyakhov and I. Mikolauskas collected them on Bol'shoy Lyakhovsky Island. Samples of woolly rhinoceros hair (LDR – P 71) from the Olenek region were presented to the museum by T. D. Krasovskaya.

4.9. References

Andreev, A.A., Tarasov, P.E., Schwamborn, G., Ilyashuk, B.P., Ilyashuk, E.A., Bobrov, A.A., Klimanov, V.A., Rachold, V., Hubberten, H.-W. (2004). Holocene paleoenvironmental records from Nikolay Lake, Lena River Delta, Arctic Russia, Palaeogeography palaeoclimatology palaeoecology, 209, 197-217.

Are, F., Reimnitz, E. (2000). An Overview of the Lena River Delta Setting: Geology, Tectonics, Geomorphology, and Hydrology.-j. of Coastal Research, 16 (4): 1083-1093.

Carson, C. E., (2001). The oriented thaw lakes: a retrospective. In Norton, D. W. (ed.), Fifty More Years Below Zero. Fairbanks, AK: Arctic Institute of North America, 129–138.

Cote, M. M., and Burn, C. R., (2002). The oriented lakes of Tuktoyaktuk Peninsula, Western Arctic Coast, Canada: a GIS-based analysis. Permafrost and Periglacial Processes, 13: 61–70.

Galabala, R.O. (1987). New data on the structure of the Lena Delta.- Quaternary period North-East Asia. SVKNIIDVO AN SSSR, 152-171, Magadan, (in Russian).

Grigoriev M.N., (1993). Cryomorphogenesis of the Lena River mouth area - Yakutsk, SO AN SSSR, 176 p. (in Russian).

Grigoriev, N.F. (1966). Perennially frozen ground of the Yakutian maritime zone. Moscow: Nauka, 1966, 180 p. (in Russian).

Gusev, A.I. (1961). Stratigraphy of Quaternary deposits of the Coastal plain, in: Materialy soveshchaniya po izucheniyu chetvertichnogo perioda, Vol. III, 1961, pp. 119-127 (in Russian).

Ivanov, O.A.. (1972). “Stratigraphy and correlation of Neogene and Quaternary deposits in subarctic plains of East Yakutia,” in: Problems of the Quaternary period study. Moscow: Nauka, 1972, pp. 202-211. (in Russian).

Kolpakov, V.V. (1983). Eolian deposits in Quaternary of Yakutia, Byulleten’ komissii po izucheniyu Chetvertichnogo perioda, Vol. 52, 1983, pp. 123-131.

Krbetschek, M. R., Gonser, G., & Schwamborn, G. (2000). Luminescence dating results of sediment sequences of the Lena Delta. Polarforschung, 70: 83-88.

Kunitsky, V.V. (1989). Cryolithology of the lower Lena region.- Permafrost Institute Press Yakutsk 162 pp. (In Russian).

Lungersgauzen, G.F. (1961). Stratigraphy of Cenozoic fundamental deposits of the middle and the lower Lena and the Lena Delta.- (In Russian).

Mikulenko, K. & Timirshin, K. (1996). Issues on geology in the arctic of West Yakutia.- In: Grigoriev, M.N. Imaev V.S. Imaeva, L.P. et al. (eds.): Geology, seismicity and cryogenic processes in the arctic areas of Western Yakutia, RAS, Siberian Branch, Yakut Scientific Centre, pp. 31-52 (In Russian).

Pavlova, E. Y. & Dorozkhina, M. V. (2000). The Holocene alluvial delta relief complex and hydrological regime of the Lena River Delta. Polarforschung, 70: 89-100.

Pavlova, E. Yu and Doroshkina, M. (2000). Geological-geomorphological studies in the western and central part of the Lena Delta.- In: Rachold, V. and Grigoriev, M.N. (eds.): Russian German Cooperation SYSTEM LAPTEV SEA 2000: The Expedition LENA 1999. Reports on Polar Research, 354: 75-90.

Pavlova, E., Dorozhkina, M., Kozlov, D. (2000). Observations of water level oscillations in the Olenyokskaya Channel; in: Rachold, V. (ed.): Reports on Polar Research - Expeditions in Siberia in 1999; 354: .90-91

Pelletier, J. D. (2005). Formation of oriented thaw lakes by thaw slumping. Journal of Geophysical Research, 110(F02018): doi:10.1029/2004JF000158.02802

Rachold, V. and M.N. Grigoriev, (eds.) (1999). “Russian-German Cooperation SYSTEM LAPTEV SEA 2000: The Lena Delta 1998 Expedition,” Reports on Polar Research, Vol. 315, 1999, 268 p.

Rachold V. and M.N. Grigoriev eds. (2000). “Russian-German Cooperation SYSTEM LAPTEV SEA 2000: The Expedition Lena Delta 1999,” Report on Polar Research, Vol. 354. 2000, 303 p.

Rachold, V. and M.N. Grigoriev. (eds.) (2001). “Russian-German Cooperation SYSTEM LAPTEV SEA 2000: The Lena Delta 2000 Expedition,” Reports on Polar Research, Vol. 388, 2001, 135 p.

Rachold, V., Grigoriev, M., & Bauch, H. A. (2000). An estimation of the sediment budget in the Laptev Sea during the last 5000 years. Polarforschung, 70: 151-157

Sachs, V.N. & S.A. Strelkov (1960).. “Mesozoic and Cenozoic of the Soviet Arctic,” in G.O. Raasch, ed. Geology of the Arctic. Proceedings of the First International Symposium on Arctic Geology held in Calgary, Alberta, January 11-13, 1960, under the Auspices of the Alberta Society of Petroleum Geologists, Vol. I, Toronto: University of Toronto Press, 1960.

Schirrmeister, L., Kunitsky, V. V., Grosse, G., Schwamborn, G., Andreev, A. A., Meyer, H., Kuznetsova, T., Bobrov, A., Oezen, D. (2003). Late Quaternary history of the accumulation plain north of the Chekanovsky Ridge (Lena Delta, Russia) - a multidisciplinary approach, Polar Geography, 27(4), 277-319.

Schirrmeister, L., V.V. Kunitsky, G. Grosse, T. Kuznetsova, S. Kuzmina, and D. Bolshiyanov (2001). “Late Quaternary and recent environmental situation around the Olenyok Channel (western Lena Delta) and on Bykovsky Peninsula,” in V. Rachold, and M.N. Grigoriev, eds., Russian-German Cooperation System Laptev Sea 2000: The Lena Delta 2000 Expedition. Reports on Polar Research, Vol. 388, 2001. 85-135.

Schneider, J. (2005). Bilanzierung von Methanemissionen in Tundragebieten am Beispiel des Lena-Deltas, Nordostsibirien, auf der Basis von Fernerkundungsdaten und Geländeuntersuchungen. Diplomarbeit, TU Dresden, 115 p.

Schwamborn, G.; Schneider, W. Grigoriev, M.N., Rachold, V. and Antonow, M. (1999): Sedimentation and environmental history of the Lena Delta. - In: Rachold, V. and Grigoryev, M.N. (eds.): Russian German Cooperation SYSTEM LAPTEV SEA 2000: The Lena Delta 1998 Expedition. Reports on Polar Research, 315: 94-111.

Schwamborn, G., Andreev, A. A., Rachold, V., Hubberten, H. W., Grigoriev, M. N., Tumskoy, V., Pavlova, E. Y., Dorozhkina, M. V.(2002a). Evolution of Lake Nikolay, Arga Island, Western Lena River delta, during Late Pleistocene and Holocene time, Polarforschung, 70, 69-82.

Schwamborn, G., Dix, J. K., Bull, J. M., Rachold, V.(2002b). High-resolution seismic and ground penetrating radar - geophysical profiling of a thermokarst lake in the western Lena Delta, Northern Siberia, Permafrost and periglacial processes, 13, 4, 259-269.

Schwamborn, G., V. Rachold, and M.N. Grigoriev.(2002c). Late Quaternary sedimentation history of the Lena Delta, Quaternary International, Vol. 89, 2002, pp. 119-134.

Ulrich, M. (2006). Charakteristik und spektrale Eigenschaften periglazialer Landschaften im Lena-Delta, NO-Sibirien; Diplomarbeit Universität Leipzig, 133 p.

4. 10 Appendices

Appendix 4-1: Field spectrometry – description of Measuring (m.) points and profiles (see chapter 4.4)

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Samoylov (Sam1)/ 12.08.2005 / 11:40 126°28'40.66" E 72° 22' 1.56" N	*Low-centre polygon at the uppermost accumulation terrace / Weather: varying to strongly clouded*	000 / 001	bareoptic / 24°	Polygon wall above, grass and moss	Point m.
		002 / 003	bareoptic / 24°	Polygon wall middle (slope), moss and Salix sp.	Point m.
		004 / 005	bareoptic / 24°	Polygon centre, wet, moss, sedge	Point m.
		006 / 007 / 008	bareoptic / 24°	Polygon centre, sediment with vegetation, minor covering, moss, sedge, Salix sp.	Point m. / sunny
		009 / 010	bareoptic / 24°	Polygon centre, sediment with vegetation in minor covering, less moss	Point m.
		011 / 012	bareoptic / 24°	Polygon slope with moss and grass	Point m.
		013 / 014 / 015	bareoptic / 24°	Polygon wall across a frost crack	Point m. / strong cloud variation
		016 - 020	bareoptic / 24°	Profile across a polygon about from N to S	Profile m.
		021 - 025	bareoptic / 24°	Profile across a polygon about from S to N	Profile m.
		026 - 029	bareoptic / 24°	Profile across a polygon about from E to W	Profile m.
		030 - 033	bareoptic / 24°	Profile across a polygon about from W to E	Profile m.
		034 / 035	8°	Salix sp.-shrub, about 15cm high, gray-green leaves and sporadic grass	Point m.
		036 / 037	8°	Area with moss (green-yellowish) and sporadic grass	Point m.
		038 / 039	8°	Sediment spot with sporadic grass and *Polygonum* sp.	Point m.
		040 / 041	8°	Area with grass, sporadic moss	Point m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Samoylov (Sam2) / 12.08.2005 / 16:30 / 126° 28' 43-43" E 72° 22' 8.18" N	Polygon with pond, profile across the slope to the banya lake at the upper accumulation niveau	000 / 001	bareoptic / 24°	Polygon wall top grass, moss, sporadic Salix sp.	Point m.
		002 / 003	bareoptic / 24°	Polygon slope, wetter underground, more moss, less grass	Point m.
		004 / 005	bareoptic / 24°	Polygon centre covered, underground very wet, sedge, less moss	Point m.
		006 / 007	bareoptic / 24°	Polygon centre, standing water, only sedge	Point m.
		008 / 009	bareoptic / 24°	Polygon pond, ca.70cm deep, non covered	Point m.
		010	bareoptic / 24°	White reference	
		011 - 012	bareoptic / 24°	Profile from polygon wall to polygon centre, about 3-4m	Profile m.
		013 - 015	bareoptic / 24°	Profile from polygon centre to polygon wall	Profile m.
		016	bareoptic / 24°	White reference	
		017 - 040	bareoptic / 24°	Profile from upper terrace (underground relative wet) across a dryer slope (2-3°) towards the banya lake, start: 126° 28' 41.99" E 72° 22' 8.61" N, en: 126° 28' 45.63" E 72° 22' 7.10" N 017 - 020 about 20m across one polygon to the next polygon centre 021 error 022 White reference ca from 035 / 036 dryer slope area	Profile m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Samoylov (Sam3) / 12.08.2005 / 18:15	Profile from the lower older to the higher terrace, Weather: diffuse sunny / Start: 126° 28' 29.03" E 72° 22' 12.54" N, End: 126° 28' 31.08" E 72° 22' 9.08" N	000	bareoptic / 24°	White reference	
		001 - 028	bareoptic / 24°	003 / 004 / 005 moss, wet	Profile m.
				008 Polygon wall, dry	
				010 / 011 moss, standing water	
				017 Polygon wall, moss	
				021 / 022 from the lower to the higher level, across a short, steep slope, relative dry	
				028 polygon wall at upper terrace	
Island Samoylov (Sam4) / 12.08.2005 / ca.19:00	Profile at niederer (episodischer) acrossflutungsterrace, Startpunkt: 126° 28' 23rd 34" E 72° 22' 13rd 47" N, Endpunkt: 126° 28' 18.95" E 72° 22' 13rd 87" N			Vegetation, sparse covered, cover range about 50%, sedge and *Salix* sp., in between non-covered dark-gray soil	
		000	bareoptic / 24°	White reference	
		001 - 012	bareoptic / 24°	001 - 004 relative dry	Profile m.
				from 005 about 5 cm deep stagnant water with up to 40cm high sedge	

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Kurungnahk (Bkh05) / 13rd 08.2005 / ca. 18:00, 126° 15' 22.57" E 72° 19' 15.88" N	Bkh05c Profile and point m.en in a drained active layerass lake of the 3rd terrace, Weather: varying clouded with sunny periods			Vegetation: relative high grass and *Salix* sp. shrubs	
		000 / 001	bareoptic / 24°	Sediment	Point m.
		002 / 003	bareoptic / 24°	Grass	Point m.
		004 / 005	bareoptic / 24°	Grass	Point m.
		006 / 007	bareoptic / 24°	*Salix sp.*-shrub 60-70cm high, underneath grass	Point m.
		008	bareoptic / 24°	White reference	
		009 - 013	bareoptic / 24°	Profile across a thermokarst mound with grass and *Salix* sp.	Profile m.
		014 / 015	bareoptic / 24°	Grass, dry	Point m.
		016 / 017	bareoptic / 24°	Sediment spot	Point m.
		018 - 024	bareoptic / 24°	Profile between thermokarst mounds with more grass	Profile m.
	Bkh05d surface of the 3rd terrace	026 - 042	bareoptic / 24°	Profile across the surface 3rd terrace with various vegetation units, *Salix* sp., moss spots, grass spots, start: 126° 15' 35.53" E 72° 19' 14.95" N, end: 126° 15' 40.03" E 72° 19' 14.91" N	Profile m.
		043 / 044	bareoptic / 24°	*Salix sp., 3rd terrace*	Point m.
		045 / 046	bareoptic / 24°	Moss spot, green, 3rd terrace	Point m.
		047 / 048	bareoptic / 24°	Grass spot, 3rd terrace	Point m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Ebe-Basy-Sise / T008 / 18.08.2005 / ca. 10:30 / 123° 48' 18.90" E 72° 57' 51.40" N	Sand area, ca. 8m above the Channel (Camp site), Weather: low windy, low cloudy, sunny			Surface conditions: sandy, dry, flat relief, vegetation: sparse covered (about 60% cover range) moss, lichens, sporadic grass up to 20cm high and herbs low vegetation, about 5 cm high	
		000	bareoptic / 24°	White reference	Point m.
		001 / 002	bareoptic / 24°	Sandy soil, dry grass, *Cassiope tetragona*, 60% cover range	Point m.
		003 / 004	bareoptic / 24°	Small wall, dry, dominantly moss (green), diverse lichens (reindeer moss), Dryas sp., relative dense covered	Point m.
		005 / 006	bareoptic / 24°	Sandy, plant cover ca.80%, moss (green), herbs, 3-4cm high	Point m.
		007 / 008	bareoptic / 24°	Reference area (ca 1x1m), sandy, dry, plant cover 50%, less moss, *Dryas* sp., *Salix* sp., *Cassiope tetragona*, *Vaccinium* sp., sporadic grass, plant height about 2cm, 123° 48' 18.14" E 72° 57' 52.66" N	Point m.
		009 / 010	bareoptic / 24°	Sand with wind ripples, light-yellowish, fine to middle sand, fluvial accumulated, aeolian reworked, without vegetation	Point m.
		011 - 020	bareoptic / 24°	Profile ca.50m from W - E across a sand area, vegetation dry, similar to reference area sparse covered, less moss, sporadic dry cotton grass,	Profile m.
		021 - 028	bareoptic / 24°	Profile from E - W across the same surface	Profile m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Ebe-Basyn-Sise / T009 / 18.08.2005 / ca. 11:30 / 123° 48' 26.39" E 72° 57' 46.64" N	Higher flood plain level (episodic flooded area) SE below the camp, about 1 -2 m above the channel level, Weather: sunny, sporadic cirrostratus			Flat relief, vegetation 30-40cm high, sedge and Salix sp. at moss, mostly tussocks, in-between stagnant, brown water, active layer in tussocks about 40cm, in-between ca. 30cm	
		000	bareoptic / 24°	White reference	
		001 / 002	bareoptic / 24°	Grass tussock (Cyperacaea) at moss about 30cm high	Point m.
		003 / 004	bareoptic / 24°	Dominantly Salix sp. at moss pillows and stagnant water	Point m.
		005 / 006	bareoptic / 24°	Grass tussock (Cyperacaea) but more green and flat	Point m.
		007 / 008	bareoptic / 24°	stagnant water, about 5cm deep, brown	Point m.
		009 - 019	bareoptic / 24°	Profile about from NW to SE about 60m, Measuring (m.) points every 4m, start: see above, end: 123° 48' 27.25" E 72° 57' 45.60" N	Profile m.
		020 - 028	bareoptic / 24°	Profile from S to N across the similar surface	Profile m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Ebe-Basyn-Sise / T010 / 18.08.2005 / ca.12:15 / 123° 48' 14.54" E 72° 57' 56.26" N	Polygon tundra, ca. 1 - 2 m lower surface level in western direction near the camp site, weather: sunny, clear			Relief to the lake slightly sloping, orthogonal low-centre polygons, 12 - 18m in diameter, centres with stagnant water, dryer walls, in average 50cm high vegetation at the walls: moss, sedge, grass, *Betula* sp., *Salix* sp., *Dryas* sp., diverse lichens, some herbs, active layer between 30 and 40cm, polygon centers: stagnant water, about 10cm deep, vegetation tussocks with Sphagnum sp. and sedge (about 30cm high), sporadic cotton grass, active layer in average 45cm	
		000	bareoptic / 24°	White reference	Point m.
		001 / 002	bareoptic / 24°	Polygon wall	Point m.
		003 / 004	bareoptic / 24°	Moss spot (Sphagnum sp.) green, wet	Point m.
		005 / 006	bareoptic / 24°	Polygon centre, stagnant water across moss, sedge in small tussocks	Point m.
		007 / 008	bareoptic / 24°	Cotton grass, relative dense covered, in stagnant water	Point m.
		009 / 010	bareoptic / 24°	Iron precipitation at the rims of a pond wetter to moister soil	Point m.
		011 / 012	bareoptic / 24°	Pond with stagnant water, grass	Point m.
		013 - 024	bareoptic / 24°	Profile across several polygons ca. from NE to SW	Profile m.
		025 - 034	bareoptic / 24°	Profile from SW to NE across the same surface	Profile m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Ebe-Basyn-Sise / T011a / 18.08.2005 / ca. 14:00 / 123° 47' 29.47" E 72° 58' 9.25" N	Flood plain in front of the alass at Ebe-Basyn-Sise, Weather: sunny, clear	Relief: slightly sloping from the alas to the channel, soil: relative wet, partly stagnant water, drift wood, vegetation dominantly *Salix* sp. and sedge at moss pillows, sporadic cotton grass areas			
		000	bareoptic/ 24°	White reference	Point m.
		001 / 002	bareoptic/ 24°	Poacea and sedge at moss pillows about 20cm high, sporadic equisetum	Point m.
		003 / 004	bareoptic/ 24°	*Salix sp.*-shrub about 30cm high, underneath grass and moss	Point m.
		005 / 006	bareoptic/ 24°	Driftwood about 2m long, 30 cm in diameter, dry, bleached	Point m.
		007 - 020	bareoptic/ 24°	Profile across the flood plain	Profile m.
Ebe-Basy-Sise / T011b / 18.08.2005 / 123° 47' 84" E 72° 58' 86" N	Flood plain, location about 200m north of T011a, 20m from the channel shore	Dominantly reddish grass (*Arctophylla* sp.), about 30 - 50cm high, in-between sporadic dry cotton grass, vegetation pressed down by wind, cover range 80 - 90%, very wet soil between the vegetation, sometimes 2 - 3cm stagnant water, active layer between 70 and 80 cm deep			
		021 / 022	bareoptic/ 24°		Point m.
Island Ebe-Basyn-Sise / T012 18.08.2005 / 123° 46' 41.09" E 72° 58' 6.26" N	Alas depression, location ca. 150 m from the elongated lake towards the channel	Relief, relative flat area, low-centre polygons, soil relative wet, medium drained, vegetation: moss and sedge, sporadic cotton grass, at dryer places more Salix sp., 20-30cm high, sporadic driftwood trunks, active layer: walls about 30 cm, in wetter places 35-40 cm			
		000	bareoptic/ 24°	White reference	Point m.
		001 / 002	bareoptic/ 24°	Wet depression (polygon centre?), moss and sedge, 20-30 cm high	Point m.
		003/004	bareoptic/ 24°	Wall, soil dry, better drained, *Salix* sp., dryer moss, sedge and grass	Point m.
		005 - 015	bareoptic/ 24°	Profile across wet polygon centres and dryer polygon walls, ca. from NW to SE	Profile m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Turakh-Sise / T019 / 25.08.2005 / 13:15 123° 50' 6.31" E 72° 58' 53rd 89" N	Alas depression,location at the southern lake, southern lake shore, weather: varying clouded, a lot of Cirrus cloudes, Measuring (m.) limited only by open sky	Vegetation, more or less unique, *Salix* sp. between partly dry grass at moss pillows, sporadic cotton grass, vegetation cover almost 100%, height about 30cm, active layer in average 30cm deep			
		000	bareoptic / 24°	White reference	Point m.
		001 / 002	bareoptic / 24°	*Salix sp.* between grass and moss pillows vegetation relative dry	Point m.
		003 / 004	bareoptic / 24°	2 cm deep, stagnant, brown water with grass (greener), about 30 cm high	Point m.
		005 / 006	bareoptic / 24°	more *Salix* sp. between dryer grass	Point m., cloudy at 006
		007 / 008	bareoptic / 24°	error	Point m., clouded
		009 - 019	bareoptic / 24°	Profile at the lake shore, 014 and 017 - 019 dominantly stagnant water	Profile m.
Island Ebe-Basyn-Sise/ T048 / 31.08.2005 / 11:40 / 123° 45' 19.56" E 72° 58' 35.17" N	Sand bluff at the channel location western edge at the end of the alas depression, weather: sunny, clear, sporadice Cirrus cloudes, light windy, about 10°C	Vegetation, very sparse covered, about 20% cover, autumnal dwarf shrub beneath dry grass and moss, plant height max. 20 cm, active layer depth about 1.05 m			
		000	bareoptic / 24°	White reference	Point m.
		001 / 002	bareoptic / 24°	Sand, dry with autumnal *Salix* sp.	Point m.
		003 - 007	bareoptic / 24°	Profile at the bluff, about 25m towards the shore (N)	Profile m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Ebe-Basyn-Sise / T049 / 31.08.2005 / 11:52 / 123° 45' 8.90" E 72° 58' 33rd 48" N	**T049a western wall of the alas , upper slope**	Hummock-surface			
		000	bareoptic/ 24°	White reference	Point m.
		001 / 002	bareoptic/ 24°	Area between hummocks with yellowish lichens and reindeer moss, *Cassiope tetragona* (dry), sporadic *Dryas* sp.	Point m.
		003/004	bareoptic/ 24°	Hummock with *Dryas* sp., *Cassiope tetragona,* reindeer moss, dry moss, scab lichens and various Ericacaea	Point m.
		005 - 020	bareoptic/ 24°	Profile across the alass wall (upper slope), start see above end: 123° 45' 2.67" E 72° 58' 31.39" N	Profile m.
		021 / 022	bareoptic/ 24°	Dry, grayish moss and yellow lichen	Point m.
	T049b	023 - 049	bareoptic/ 24°	Profile from transition area to the tundra across alas rim to the alas depression, start: 123° 44' 58.32" E 72° 58' 34.09" N end: 123° 45' 10.23" E 72° 58' 30.38" N	Profile m.
		050 / 051	bareoptic/ 24°	*Cassiope tetragona*	Point m.
Island Ebe-Basyn-Sise / T050 / 31.08.2005 / 12:26 / 123° 45' 6.67" E 72° 58' 35.21" N	*low-centre polygon, transitions area between alas rim to the tundra, Weather, (see T048)*	Polygon about 10 - 12 m in diameter, polygon centre about 6 m, about 50 - 80 cm high polygon walls, vegetation: polygon centres, 10 cm deep stagnant water with dominantly sedge (30 - 40 cm high), partly sere, about 60% cover, polygon walls dry, similar to alass rims with lichens, moss, less grass			
		000 / 001	bareoptic/ 24°	Polygon centre	Point m.
		002 / 003	bareoptic/ 24°	Polygon wall	Point m.
		004 - 022	bareoptic/ 24°	Profile across several polygons, start: see above end: 123° 44' 55.37" E 72° 58' 34.81" N	Profile m.
		023 / 024	bareoptic/ 24°	Water, small pond, about 50cm deep, with thin ice cover	Point m.
		025/026	bareoptic/ 24°	Pond shore, moss spot (*Sphagnum* sp., green-yellowish, very wet) and grass	Point m.
		027/028	bareoptic/ 24°	Pond shore, moss spot (*Sphagnum* sp., green-yellowish, very wet) with sporadic grass blades	Point m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Ebe-Basyn-Sise / T051 / 31.08.2005 / 13:28 / 123° 45' 0.55" E 72° 58' 28.04" N	Alas depression, several surface structures, constant weather conditions			Surface conditions very wet, with stagnant water, unclear polygon pattern elongated polygon walls parallel to the alas rim, and to the lake shore, without clear cross links and between depressions of polygon centres, very wet, bad drained	
		000	bareoptic/ 24°	White reference	Point m.
	T051a	001 / 002	bareoptic/ 24°	Western slope foot of the alas rim, characteristic for an about 20 m wide sedge zone about 20 - 30cm high, on *Sphagnum* sp.-pillows partly dry (50:50)	Point m.
		003 - 023	bareoptic/ 24°	Profile across the NW-part of the alas depression towards a silted-up lake (boggy) lake, from the slope base of the alas rim across alternation of elongated polygon walls (slope parallel) and depressions with stagnant water, start: see above end: 123° 45' 10.49" E 72° 58' 25.88" N	Profile m.
		024 / 025	bareoptic/ 24°	Spot with green-yellowish moss, sporadic grass and finger lichens	Point m.
		026 / 027	bareoptic/ 24°	Micro pingo in the silted-up, boggy lake, with dominantly dry grass, underneath moss pillows, sporadic cotton grass	Point m.
	T051b	028 / 029	bareoptic/ 24°	Silted-up, boggy part of an alas lake with greenish *Arctophylla* sp. and cotton grass, water depth about 5 - 10cm above moss pillows, penetration depth into moss min. 30 m to the permafrost level	Point m.
		030 / 031	bareoptic/ 24°	Similar surface conditions like 028 / 029, but more Sphagnum sp. at the water surface and reddish *Arctophylla* sp.	Point m.
		032 / 033	bareoptic/ 24°	Similar surface conditions dominantly reddish *Arctophylla* sp. and green Sphagnum sp. at the water surface	Point m.
		034 / 035	bareoptic/ 24°	Smaller reddish *Arctophylla* sp. and green-brownish *Sphagnum* sp. below water surface	Point m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Ebe-Basyn-Sise / T052 / 31.08.2005 / 14:13 / 123° 45' 34.32" E 72° 58' 24.80" N	Drift wood zone at the northern bluff, which border the alas to the channel			White reference	
		001 - 010	bareoptic/ 24°	Profile across the drift wood zone, start: see above, end: 123° 45' 38.42" E 72° 58' 23rd 22" N	Profile m.
		011 / 012 / 013 / 014	bareoptic/ 24°	Drift wood trunks	Point m.
Island Ebe-Basyn-Sise / T053 / 31.08.2005 / 15:52 / 123° 48' 30.02" E 72° 57' 46.82" N	higher flood plain level(episodically flooded area), (see T009)			Renewed point m. and profiles at the lower flood plain level, vegetation: see T009, but now autumnally colored and dryer grass, 20 - 30 cm high, active layer between 35 and 40 cm deep	
		000	bareoptic/ 24°	White reference	Point m.
		001 / 002	bareoptic/ 24°	Autumnal *Salix* sp. and dryer grass at moss pillows	Point m.
		003 - 021	bareoptic/ 24°	Profile across the upper flood plain level to the lower level, transition ca. at point 011, small and flat bluff, about 1,50 m high, start: see above end: 123° 48' 41.76" E 72° 57' 44.45" N	Profile m.
		022 / 023	bareoptic/ 24°	Lowest flood plain level 30-40 cm high, autumnal Salix sp.-shrubs, underneath partly dry grass about 20 cm high, active layer in average 70cm deep	Point m.
		024 / 025	bareoptic/ 24°	Grass spot about 2 m in diameter, without Salix sp., grass about 10 cm high, dry	Point m.
		026	bareoptic/ 24°	White reference	Point m.
		027 / 028	bareoptic/ 24°	Reference area (see T008), vegetation: autumnal, silty surface because of frequent precipitation	Point m.

Appendix 4-1: Continuation

Position /date / time / coordinates	Location / Weather conditions	Record No.	Optic	Characteristics: Surface / Vegetation	Measuring (m.) process / Remark
Island Turakh-Sise / T054 / 31.08.2005 17:41 / 123° 48' 04" E 72° 58' 29.95" N	at the slip-off slope of a meandering brook valley, small valley from the channel to the 1st alas lake	Vegetation, dominantly grass and sedge to 40 cm high at dry moss pillows smaller areas with autumnal *Salix* sp., Changing moisture conditions from the brook (wet) to the slope (relative dry)			
		000	bareoptic/ 24°	White reference	Point m.
		001 / 002	bareoptic/ 24°	Green grass and sedge, about 10-15 cm high, with dryer places, 3 m distance to the brook shore, active layer 25 to 40 cm deep	Point m.
		003 / 004	bareoptic/ 24°	Brook shore, reddish *Arctophylla* sp. directly at the water surface	Point m.
		005 / 006	bareoptic/ 24°	*Arctophylla sp.* less frequent below and above the water level	Point m.
		007 / 008	bareoptic/ 24°	Brook, floating water, about 25cm deep, brown brook bottom	Point m.
		009 - 019	bareoptic/ 24°	Profile across slip-off slope to the valley slope crossing several surfaces, start: see above, end. 123° 48' 37.65" E 72° 58' 31.64" N	Profile m.
		020 / 021	bareoptic/ 24°	Polygon tundra at the upper slope of the valley slope, transition to the alas depression, only polygon centre measured	Point m.

Appendix 4-2: List of sediment samples (see chapter 4.5)

No	sample	height [m asl]	height [m]	depth [m]	lithology	colour	cryo-structure	ice abs.	ice grav.
Kurungunakh Island, drained thermokarst lake, old lake bottom; 72.3219 °N, 126.4786 °E, 13.08.2005									
1	Bkh-05-3			0.6	lake deposits, organic-rich, silt	dark grey	unfrozen		
2	Bkh-05-1			0.1		dark grey	unfrozen		
3	Bkh-05-2			0.34	lake deposit, peat inclusion	dark brown	unfrozen		
Ebe-1: fox cave on Ebe Sise Island, 72,9430 °N, 123,6314 °E; 19.08.2005									
4	Ebe-1-1			0.2	fine sand (fox cave)	light-brown	unfrozen		
Ebe-2: dig on Ebe Sise Island, hill slope near thermokarst lake, 72,9279 °N, 123,6079 °E, 19.08.2005									
5	Ebe-2-S-1			0.94	fine sand	grey	massive	16	19.1
6	Ebe-2-S-2			0.85				15.8	18.8
7	Ebe-2-S-3			0.75	fine sand, banded/ bedded, buried soil?	grey	unfrozen		
8	Ebe-2-S-4			0.6	silty fine sand, modern roots, not bedded	greyish-brown	unfrozen		
9	Ebe-2-S-5			0.4	soil, organic rich, silty fine sand, roots	brownish	unfrozen		
10	Ebe-2-S-6			0.2	uppermost soil horizon,	brown	unfrozen		
Ebe-3: dig on Ebe Sise Island, hill slope near thermokarst lake, 72,9267 °N, 123,6033 °E, 19.08.2005									
11	Ebe-3-S-1			0.6	fine-sand, Fe oxid impregnations, bands, rings	brownish-grey	massive, small ice veins	20.2	25.3
12	Ebe-3-S-2			0.5				23.6	31
13	Ebe-3-S-3			0.4				19.7	24.5
Ebe-4: exposure below the camp site, 72,9653°N, 123,8071°E, 22.08.2005									
14	Ebe-4-1	6.411		0.35	sand, modern roots, banded	grey	unfrozen		
15	Ebe-4-2	6.011		0.75	fine-sand, spotty, roots, dark denser layers	grey, dark grey, brownish	unfrozen		
16	Ebe-4-3	5.761		1	fine-sand, middle-sand, roots		unfrozen		
17	Ebe-4-4	5.261		1.5	silty fine-sand, alterations, banded 2 cm, organic	grey, dark grey			
18	Ebe-4-5	5.011		1.75	fine-sand, middle-sand, roots	yellowish-grey	unfrozen		
19	Ebe-4-6	4.561		2.2	fine-san, middle-sand, roots	grey, brownish	massive	17,6	21.4
20	Ebe-4-7	4.311		2.45	fine-sand, peat inclusion	grey, brown	massive		
21	Ebe-4-8	4.161		2.6	peat inclusion, fine-sand, frost crack with sand filling	grey, yellowish	massive	22.6	29.3
22	Ebe-4-9	3.911		2.85	peat, cryoturbation fine sand	brown		50.4	101.8
23	Ebe-4-10	3.761		3		brown, grey	massive	26.1	35.4
24	Ebe-4-11	3.611		3.15		brown	polozatik		
25	Ebe-4-12	3.361		3.4	peat clast, fine-sandy matrix	brown, yellowish-grey			
26	Ebe-4-13	3.111		3.65	fine-sand, weakly bedded, plant detritus	greyish-brown, yellowish	massive	19.5	24.1
27	Ebe-4-14	2.761		4					
28	Ebe-4-15	2.561		4.2	fine-sand, spotty	lighter	massive	16.7	20
29	Ebe-4-16	2.211		4.55	fine-sand	yellowish-grey	massive	17,6	21.4
30	Ebe-4-17	1.911		4.85				19.3	23.9

Appendix 4-2: Continuation

No	sample	height [m asl]	height [m]	depth [m]	lithology	colour	cryo-structure	ice abs.	ice grav.
Ebe-5: exposure south on Ebe Sise Island, 72.92 °N, 123.68 °E, 31.08.2005, V. Kunitsky, T. Kuznetsova									
31	Ebe-5-1		3.2		middle to fine sand, ripple bedded,	grey	massive		
32	Ebe-5-2		3.6		middle to fine sand, bedded,	grey	massive		
33	Ebe-5-3		3.9		middle to fine sand, bedded,	grey	unfrozen		
34	Ebe-5-4		4.05		middle to fine sand, fine laminated,	grey	unfrozen		
35	Ebe-5-5		4.75						
36	Ebe-5-6		5						
Exposure near the drill site on Turakh Island, 72.9740 °N, 123.7986 °E, 18./20.08.2005									
42	Tur-1-S-14	5.18		0.2	fine sand, dunes	light-grey	unfrozen		
41	Tur-1-S-13	4.78		0.6	fine sand, dune, bedded	light-grey	unfrozen		
40	Tur-1-S-12	4.58		0.8	fine sand, banded, buried soil	grey to dark-brown	unfrozen		
39	Tur-1-S-11	4.49		0.9	fine sand, buried soil, banded	grey to dark-brown	unfrozen		
38	Tur-1-S-10	4.38		1	driftwood	brown	unfrozen		
52	Tur-1-S-9	4.38		1.0	alluvial peat, dense, bedded	dark-brown	unfrozen		
51	Tur-1-S-8	4.28		1.1					
	Tur-OSL-4 (Tur-1)	2.88		2.5	fine-sand, middle sand, peat inclusions				
49	Tur-1-S-6	4.08		1.3	sand, Fe-oxid impregnations, banded	greyish/brown	massive, ice veins	26.7	36.3
50	Tur-1-S-7	4.18		2.7	alluvial peat, dense, bedded	dark-brown	unfrozen		
48	Tur-1-S-5	3.58		2.9	sand, fine grained	yellowish-grey	massive	9	9.9
47	Tur-1-S-4	3.38		3	sand, single small peat inclusions	grey	ice schliers, diagonal	29.1	41
46	Tur-1-S-3	2.88		2.5	peat inclusion, near the long ice wedge	dark-brown	massive	43.4	76.8
	Tur-OSL-3 (Tur-1)	2.88		2.5	fine-sand, middle-sand, organic, spotty				
45	Tur-1-S-2	2.58		2.8	sand	yellowish	massive	24.5	32.5
37	Tur-1-S-1	1.38		4.0	sand, without structures	yellowish-grey	massive	17	20.5
43	Tur-1-S-15	1.18		4.2	fine sand, middle sand alternation, cross bedded	greyish-brown	massive, small ice veins		
	Tur-OSL-2 (Tur-1)	0.88		4.5	fine-sand, middle-sand, weakly bedded				
44	Tur-1-S-16	0.88		4.5	fine sand, middle sand, alternation, cross bedded	greyish-brown	massive, small, thin ice veins		

Appendix 4-2: Continuation

No	sample	height [m asl]	Sample interval	depth [m]	lithology	colour	cryo-structure	ice abs.	ice grav.
Tur-2: Drill core on Turakh Island, 72,97401°N, 12379858°E, 20., 23., 24., 26. 27.29. 8. 2005									
53	Tur-2-1	0.477	1-1.1	1.04	fine-sand, like in the outcrop Tur-1	grey	massive		
54	Tur-2-2	0.317	1.1-1.25	1.2	fine sand	grey	ice wedge, 1.5 cm broad,		
55	Tur-2-3	0.227	1.25-1.35	1.29	fine-sand	grey			
56	Tur-2-4	0.147	1.35-1.40	1.37	fine sand	grey			
57	Tur-2-5	0.067	1.40-1.50.	1.45	fine-sand	grey			
58	Tur-2-6		1.50-1.53	1.515	ice wedge				
59	Tur-2-7	-0.03	1.53-1.60	1.55	fine-sand	grey			
60	Tur-2-8	-0.12	1.60-1.70	1.64	fine-sand	grey	massive	16.2	19.4
61	Tur-2-9	-0.35	1.83-1.90	1.87	fine-sand	grey	massive		
62	Tur-2-10	-0.43	1.90-2.00	1.95	fine-sand,	grey	massive		
63	Tur-2-11	-0.52	2.05-2.10.	2.04	fine-sand	greyish-brown	massive	13.2	15.1
64	Tur-2-12	-0.63	2.1--2.20.	2.15					
65	Tur-2-13	-0.73	2.20-2.30	2.25					
66	Tur-2-14	-0.82	2.30-2.40.	2.34					
67	Tur-2-15	-0.91	2.40-2.55	2.43	bedded, thin silt interbeds, fine-sand	greyish-brown	massive	18.6	22.9
68	Tur-2-16	-1.04	2.40-2.55.	2.56					
69	Tur-2-17	-1.09	2.60-2.75.	2.61					
70	Tur-2-18	-1.27	2.75-2.85	2.79					
71	Tur-2-19	-1.88	3.35-3.45	3.4	fine-sand	greyish-brown	massive		
72	Tur-2-20	-2.02	3.50-3.60.	3.54	fine-sand	greyish	massive	19.1	23.6
	Tur-OSL-1-gamma	-2.09	3.60-3.65.	3.61	fine sand, middle-sand				
	Tur-OSL-1 (Tur-2)	-2.18	3.65-3.77,	3.7					
73	Tur-2-21	-2.3	3.80-3.85.	3.82		greyish-brown	massive		
74	Tur-2-22	-2.38	3.85-3.95	3.9	middle to coarse-sand, interbeds, 5-10 cm layers	light grey, yellowish	massive	18.4	22.6
75	Tur-2-23	-2.49	3.95-4.09	4.01	fine-sand	grey	massive		
76	Tur-2-24	-2.59	4.09-4.12.	4.11	middle-sand, bedded	light-grey, yellowish	massive		
77	Tur-2-25	-2.63	4.12-4.18.	4.15	fine-sand, bedded, 1mm organic layers	brownish-grey	massive	18.8	23.2
78	Tur-2-26	-2.69	4.18-4.25	4.21	middle sand	yellowish-brown	massive		
79	Tur-2-27	-2.8	4.25-4.37	4.32	middle-sand			14.9	17.4
80	Tur-2-28	-2.99	4.50-4.55.	4.51	middle-sand				
81	Tur-2-29	-3.17	4.64-4.74.	4.69	fine-sand	greyish-brown	massive	18.4	22.6
82	Tur-2-30	-3.36	4.85-4.92.	4.88	fine-sand		massive		
	Tur-OSL-5	-3.48	4.95-5.07,	5	middle to fine-sand				
83	Tur-2-31	-3.63	5.13-5.19.	5.15	middle-sand	brown	massive		
84	Tur-2-32	-3.69	5.19-5.25.	5.21	middle-sand	brown	massive	17,4	21
85	Tur-2-33	-3.82	5.30-5.35	5.34	interbedding, middle to fine-sand, 1 cm, black grains, organic remains	brown to greyish-brown	massive		
86	Tur-2-34	-3.88	5.37-5.45.	5.4				19.4	24

Appendix 4-2: Continuation

No	sample	height [m asl]	Sample interval	depth [m]	lithology	colour	cryo-structure	ice abs.	ice grav.
87	Tur-2-35	-4.05	5.55-5.60.	5.57	middle to coarse-sand	brown	massive		
88	Tur-2-36	-4.13	5.,6-5.7,	5.65	graded bedding, fine to middle-sand, small laminaes	brown to grey	massive	19.2	23.7
89	Tur-2-37	-4.21	5.70-5.78.	5.73			massive		
90	Tur-2-38	-4.28	5.78-5.83.	5.8	fine-sand	grey	ice rich		
91	Tur-2-39	-4.34	5.83-5.88	5.86	ice		ice wedge, vertical gas bubbles	42.7	74.6
92	Tur-2-40	-4.38	5.88-5.95.	5.9	fine sand to middle-sand	greyish-brown	massive		
93	Tur-2-41	-4.48	5.95-6.02.	6	middle sand, oxidation spots	brown	massive		
94	Tur-2-42	-4.55	6.02-6.10.	6.07	middle sand, ox. spots, -bands, pedogene, organic	brown	massive	16.4	197
95	Tur-2-43	-4.63	6.10-6.20.	6.15			massive		
96	Tur-2-44	-4.73	6.20-6.30.	6.25					
97	Tur-2-45	-4.8	6.36-6.43	6.32			massive		
98	Tur-2-46	-4.88	6.36-6.43	6.4			massive	22.2	28.5
	Tur-OSL-6	-4.98	6.43-6.58	6.5					
99	Tur-2-47	-5.09	6.58-6.66.	6.61	fine sand, organic inclusions 2 mm, ox. Spots	grey, brown	massive		
100	Tur-2-48	-5.17	6.66-6.73	7,69			massive		
101	Tur-2-49	-5.26	6.73-6.79.	6.78			massive	25.3	33.9
102	Tur-2-50	-5.32	6.83-6.87	6.84			massive		
103	Tur-2-51	-5.38	6.87-6.92	6.9					
104	Tur-2-52	-5.42	6.92-6.98	6.94	fine sand, ox. spots	grey, orange-brown	massive		
105	Tur-2-53	-5.49	6.98-7,06	7,01	fine sand, organic, ox. Spots		massive		
106	Tur-2-54	-5.59	7,06-7,13	7,11	fine sand, grey, organic, twigs, ox. Spots	grey, brown		19.7	24.5
107	Tur-2-55	-5.73	7.19-7.30	7,25	fine to middle sand, ox. spots, organic	grey, orange-brown	massive		
108	Tur-2-56	-5.82	7,30-7,38.	7,34	fine to middle sand, organic	grey, brown	massive		
109	Tur-2-57	-5.88	7,38-7,44	7,4	middle sand, organic, ox. spots	grey, brown, dark-brown	massive		
110	Tur-2-58	-5.98	7,44-7,53	7,5	middle to fine-sand, plant inclusions 1-2 mm, ox. spots;	grey, brown	massive	19.6	24.4
111	Tur-2-59	-6.09	7,57-7,65.	7,61	middle to fine-sand, plant inclusions	grey, brown			
112	Tur-2-60	-6.17	7,65-7,71.	7,69	fine to middle sand, weakly bedded, ox. spots;	grey, brown		18.9	23.3
113	Tur-2-61	-6.26	7,75-7,82	7,78	fine to middle-sand, weakly bedded, ox. spots;	grey, brown			
114	Tur-2-62	-6.34	7,82-7,90.	7,86	fine to middle-sand, weakly bedded, ox. spots;				
115	Tur-2-63	-6.42	7,90-7,98	7,94	fine sand, silt, organic, ox. spots, weakly bedded	grey, orange-brown	massive	22.8	29.5

Appendix 4-2: Continuation

No	sample	height [m asl]	Sample interval	depth [m]	lithology	colour	cryo-structure	Ice abs.	ice grav.
116	Tur-2-64	-6.54	8.01-8.11.	8.06	fine sand, silt, organic-rich, ox. spots	grey, light-brown, orange-brown			
117	Tur-2-65	-6.59	8.11-8.14.	8.11	fine to middle-sand, silt, organic-rich, ox.spots	grey, light-brown, orange-brown	massive		
118	Tur-2-66	-6.63	8.14-8.19.	8.15	fine sand, organic, ox.spots	grey, orange-brown	massive		
119	Tur-2-67	-6.7	8.19-8.24.	8.22	middle sand, ox.spots, fine-sand, bedded	grey, brownish	massive	22.2	28.6
120	Tur-2-68	-6.78	8.26-8.35.	8.3	fine sand, weakly bedded	grey			
121	Tur-2-69	-6.86	8.33-8.43.	8.38	middle to fine-sand, organic-rich, plant remains				
122	Tur-2-70	-6.94	8.43-8.47,	8.46	fine sand	grey			
123	Tur-2-71	-6.98	8.47-8.53.	8.5	fine sand, middle-sand band	grey, brownish	small ice cristalls		
124	Tur-2-72	-7,08	8.56-8.65	8.6	fine-sand, middle-sand, small ox.spots, weakly bedded, organic	grey			
125	Tur-2-73	-7,15	8.65-8.69.	8.67	middle-sand	light-grey			
126	Tur-2-74	-7,23	8.69-8.77	8.75	fine sand, organic; 8.78-8.80 ice content	grey		21.2	26.9
127	Tur-2-75	-7,33	8.80-8.91.	8.85	fine to middle-sand, bedded, organic-rich	grey, brownish			
128	Tur-2-76	-7,45	8.93-90.1	8.97	fine sand, plant remains, twigs, roots; 9.01-9.02 ice content	grey, brownish	massive	47.2	89.3
129	Tur-2-77	-7,55	9.02-9.13	9.07	fine sand, organic rich layer, mica layer, bedded	grey	massive		
130	Tur-2-78	-7,62	9.13-9.21	9.14	peaty, fine to, middle-sand, plant remains; 9.21-9.23 ice content	grey, brown, light-grey	massive	23.0	29.8
131	Tur-2-79	-7,73	9.23-9.27,	9.25	middle-sand, bedded	light-grey			
132	Tur-2-80	-7,78	9.27-9.33	9.3	fine to middle-sand, weakly bedded	grey, light-grey			
133	Tur-2-81	-7,83	9.33-9.38.	9.35	fine-sand, organic-inclusion	grey			
134	Tur-2-82	-7,87	9.38-9.43.	9.39	fine-sand	grey			
135	Tur-2-83	-7,95	9.43-9.51.	9.47	bedded, organic-rich layers, fine-sand, mica-layers	grey, brownish			
136	Tur-2-84	-8.03	9.51-9.58.	9.55	fine-sand, organic, mica				

Appendix 4-2: Continuation

No	sample	height [m asl]	Sample interval	depth [m]	lithology	colour	cryo-structure	ice abs.	ice grav.
137	Tur-2-85	-8.17	9.79-8.4.	9.82	middle to fine-sand, spotty, mica	grey, light-brown			
138	Tur-2-86	-8.3	9.84-9.94.	9.89	middle to fine-sand, spotty, mica	grey	massive		
139	Tur-2-87	-8.37	9.94-10.6.	10	middle to, fine-sand, spotty, organic, mica	grey, brownish		26.4	35.8
140	Tur-2-88	-8.48	10.06-10.10.	10.02	middle sand, greyish-brown, mica				
142	Tur-2-89	-8.56	10.10-10.15.	10.08	middle sand, spotty	grey, light-brown			
143	Tur-2-90	-8.65	10.15-10.20	10.17	fine to middle-sand, mica, weakly bedded	grey	massive		
144	Tur-2-91	-8.71	10.20-10.26	10.23	fine to middle-sand, organic, weakly bedded, mica	grey, brown			
145	Tur-2-92	-8.78	10.26-10.34	10.3	fine sand	grey		21.9	28
146	Tur-2-93	-8.85	10.34-10.41	10.37	fine to middle-sand, spotty	grey	massive		
147	Tur-2-94	-8.93	10.41-10.50.	10.45	middle to fine-sand, weakly bedded, organic, spotty		massive		
148	Tur-2-95	-9.01	10.50-10.57,	10.53	middle to fine-sand, organic, roots, twigs, weakly bedded	brown, grey	massive	21.6	27.6
149	Tur-2-96	-9.08	10.57-10.62	10.6	middle sand	brown	massive		
150	Tur-2-97	-9.14	10.62-10.70	10.66	fine to middle-sand, spotty	grey, brownish	massive		
151	Tur-2-98	-9.21	10.70-10.77,	10.73	fine to middle-sand, spotty	grey, brownish	massive	18.2	22.2
152	Tur-2-99	-9.3	10.77-10.86.	10.82	fine sand	ray			
153	Tur-2-100	-9.36	10.86-10.90.	10.88	fine-sand	grey			
154	Tur-2-101	-9.4	10.90-10.95.	10.92	fine-sand	gra			
155	Tur-2-102	-9.48	10.95-11.05.	11	middle sand, spotty, black sulphide spots	brown, grey		17.6	21.4
156	Tur-2-103	-9.58	11.05-11.14.	11.1					
157	Tur-2-104	-9.65	11.14-11.20.	11.17	fine-sand, middle-sand,	grey			
158	Tur-2-105	-9.71	11.20-11.27,	11.23	fine-sand, middle-sand, weakly bedded, coal-like black inclusions	brownish-grey, black			
159	Tur-2-106	-9.78	11.27-11.34.	11.3					
160	Tur-2-107	-9.85	11.34-11.43.	11.37				17.6	21.4

Appendix 4-2: Continuation

No	sample	height [m asl]	height [m]l	depth [m]	lithology	colour	cryo-structure	ice abs.	Ice grav.
Kha-1: Khardang Island, lower sands, 72.9500 °N, 124.2080 °E, 26.08.2005									
161	Kha-1-1		0		fine to middle sand, cross-bedded,	grey	massive		
162	Kha-1-2		0.4		fine-sand, middle-sand, fine-bedded	grey	massive	16.7	20.1
163	Kha-1-3		0.8						
164	Kha-1-4		1						
165	Kha-1-5		1.5					24.5	32.4
166	Kha-1-6		1.6						
	Kha-OSL-1		2		fine-sand, middle-sand, fine-bedded	grey	massive		
	Kha-OSL-2		4			grey	massive		
Kha-2: Khardang Island, lower sand to Ice Complex, 72.9510 °N, 124.2220 °E, 27./30.08.2005									
167	Kha-2-1		3.1		peat inclusion	brown	massive		
168	Kha-2-2		4		fine sand, bedded	grey	massive	20.5	25.7
169	Kha-2-3		4.2		peat inclusion	brown	massive	35.3	54.7
170	Kha-2-4		4.4		fine sand, horizontal bedded	grey	massive		
171	Kha-2-5		4.6		peat, cryoturbation	brown	massive		
172	Kha-2-6		4.8		peat, moss	brown	massive		
173	Kha-2-7		5		peat, moss	brown	banded	51.3	105.3
174	Kha-2-8		5.2		peat, moss	brown	massive		
175	Kha-2-9		5.4		peat, moss	brown	massive		
176	Kha-2-10		5.5		peat, moss	brown	massive		
	Kha-U/Th-1		5.4		peat, moss	brown	massive		
	Kha-U/Th-2		5.3		peat, moss	brown	massive		
	Kha-U/Th-3		5.2		peat, moss	brown	massive		
	Kha-U/Th-4		5.1		peat, moss	brown	massive		
	Kha-U/Th-5		5		peat, moss	brown	massive		
177	Kha-2-11		5.8		silty fine sand, cross bedded	brownish-grey	massive		
178	Kha-2-12		6.5		sand	grey, brown	massive		
179	Kha-2-13		6.6		peat	brown	massive		
180	Kha-2-14		6.9		fine sand, bedded	grey	massive		
181	Kha-2-15		7,3		fine sand, bedded	yellowish-grey	massive		
182	Kha-2-16		7,8		silty fine sand, aleurite	darkgrey, brown	banded	30.5	43.9
183	Kha-2-17		8.2		sand, wavy bedded, cryoturbation, soil	grey, brown	banded	20.8	26.3
184	Kha-2-18		8.6		silty fine sand, aleurite,	dark-grey, brown	banded	27.4	37.7
185	Kha-2-19		7,7		fine sand, bedded	yellowish-grey	massive		
186	Kha-2-20		8.2		silty fine sand, (aleurite) plant remains	dark-grey, brown	lense-like reticulated	49.1	96.3
187	Kha-2-21		8.7						
188	Kha-2-22		9.2					32.3	47.6
189	Kha-2-23		9.8		peat inclusion	brown	massive		
190	Kha-2-24		10.1		peat inclusion	brown	massive	18.6	22.9
191	Kha-2-25		10.5		silty fine sand, aleeurite,	darkgrey, brown	lense-like reticulated		

Appendix 4-2: Continuation

No	sample	height [m asl]	height [m]l	depth [m]	lithology	colour	cryo-structure	ice abs.	ice grav.
192	Kha-2-26		11		silty fine sand, alevrit, twigs	dark-grey, brown	lense-like reticulated, banded	47.8	91.6
193	Kha-2-27		11.4		silty fine sand, alevrit,	dark-grey, brown	banded, broken lenses	33.2	49.6
194	Kha-2-28		14.5		silty fine sand, alevrit, twigs	dark-grey, brown	lense-like reticulated, banded	49.3	97.1
195	Kha-2-29		15.1		silty fine sand, alevrit	dark-grey, brown	lense-like reticulated, banded		
196	Kha-2-30		15.5		silty fine sand, alevrit, organic inclusions	dark-grey, brown	lense-like reticulated, banded	53.2	113.6
197	Kha-2-31		16		peat inclusion, paleo sol	brownish -grey	lense-like reticulated, banded	33.7	50.8
198	Kha-2-32		16.5		silty fine sand, alevrit, organic inclusions	brownish -grey	lense-like reticulated, banded	46.1	85.4
199	Kha-2-33		16.9		silty fine sand, alevrit	dark-grey, brown	lense-like reticulated, banded		
Kka-3, Khardang Island, polozatik ice wedge, 72,94975°N, 124,21307 °E, 30.08.2005									
200	Kha-3-1		4.5		fine sand	yellowish -grey	massive		
201	Kha-3-2		4.8		peat	brown	massive		
202	Kha-3-3		5.4		peat	brown	massive		
203	Kha-3-4		6.4		fine sand, organic, sulphid spots	yellowish -grey, black	massive		
T 021, Turakh Island, sand profile, 73.00 °N, 123.830 °E, 26.08. 2005									
204	T 021-0			0.1	fine to middle sand, dune	grey	unfrozen		
205	T 021-1			0.2		grey	unfrozen		
206	T 021-2			0.3	fine to middle sand, dune, organic, ox. horizon	spotty, brownish	unfrozen		
207	T 021-3			0.35	fine sand, roots, bedded	yellowish -grey	unfrozen		
208	T 021-4			0.5	fine sand, organic remains, ox. band	orange, grey	unfrozen		
209	T 021-5			0.7	fine sand, schlieres	light to dark orange, grey	unfrozen		
210	T 021-6			0.8					
211	T 021-7			0.9	fine sand, bedded	orange, grey	unfrozen		
212	T 021-8			1.1	fine sand, bedded	orange, grey	unfrozen		
213	T 021-9			1.3	fine sand	orange, grey	frozen, sand wedges, lattice like	13.0	14.9
214	T 021-10			1.6	fine sand				
215	T 021-11			1.8	fine sand			16.6	19.9

Appendix 4-3: Modern soil profiles and surface samples

No	sample	height [m]l	depth [m]	lithology	colour
Samoylov Island, 72.3679 °N, 126.4796 °E, 12.08.2006					
216	Sam 1 O	0.28	0 - 0.1	organic surface material, fine-sand	
217	Sam 1 Ah		0.1 - 0.12	soil material, silt, sand	2.5 Y 2.5/1 (Munsell)
218	Sam 1B1w(M1)		0.12 - 0.15	soil material, silt, sand	2.5 Y 3/1
219	Sam 1 B2wj(M2)		0.15 - 0.22	soil material, silt, sand	2.5 Y 3/2
220	Sam 1 B3jj(M3)		0.22 - 0.28	soil material, silt, sand	2.5 Y 2.5/1
Samoylov Island, 72.3712 °N, 126,4748 °E, 12.08.2006					
221	Sam 4 Ah(MAh)	0.45	0 - 0.03	soil material, fine-sand	2.5 Y 3/3
222	Sam 4 Oi1(fOM)		0.03 - 0.06	soil material, silt, sand	2.5 Y 2.5/1
223	Sam 4 Oi2(fO)		0.06 - 0.12	soil material, peat	10 YR 3/4
224	Sam 4 ABg(AhGo)		0.12 - 0.17	soil material, silt, sand	2.5 Y 2.5/1
225	Sam 4 Bg1(Go)		0.17 - 0.22	soil material, middle-sand	5 Y 2.5/2 (2.5 YR 2.5/4 rust spots)
226	Sam 4 Bg2(Gr)		0.22 - 0.45	soil material, fine sand, middle-sand	3/10 Y
227	Tur Lake 1			drift wood	
228	Tur Lake 2			drift wood	
229	Tur Lake 3			drift wood	
230	Tur Lake 4			drift wood	
231	Tur Lake 5-1 C	0.6	0.5 - 0.6	soil material, lake deposits, sand	dark greyish
232	Tur Lake 5-2 L(Fhh)		0.3 - 0.5	soil material, peat, sand, limnic	
233	Tur Lake 5-3 Oi(Hn2)		0.1 - 0.3	soil material, peat	
234	Tur Lake 5-4 Oe(Hnb)		0 - 0.1	soil material, peat	
235	Tur Lake 5-r			modern lake surface deposit, sand	
236	Tur Lake 6-1			sand	
237	Tur Lake 6-2			sand	
238	Tur Lake 7-1			sand	
239	Tur Lake 7-2			sand	
240	Tur Lake r 2			sand	
241	Tur Lake r 3			sand	
242	Tur Lake-9-1 Ah(O)	0.75	0 - 0.03	soil material, fine-sand	
243	Tur Lake-9-1 Abjj(Abv)		0.03 - 0.36	soil material, middle-sand	
244	Tur Lake-9-1 Bjj(Cv)		0.36 - 0.46	soil material, middle-sand	
245	Tur Lake-9-1 Bw(IICv)		0.46 - 0.75	soil material, middle-sand	
246	Tur-Lake 9-2 Ah1(Ah)	0.8	0 - 0.05	soil material, fine-sand	
247	Tur-Lake 9-2 Bjj(MCv)		0.05 - 0.13	soil material, middle-sand	
248	Tur-Lake 9-2 Ah2(fAh)		0.13 - 0.2	soil material, middle-sand	
249	Tur-Lake 9-2 Bw1(Cv1)		0.2 - 0.4	soil material, middle-sand	
250	Tur-Lake 9-2 Bw2(Cv2)		0.4 - 0.8	soil material, middle sand	

Appendix 4-3: Continuation

251	Tur Lake 9-3 Bg1(Go)	0.7	0.03 - 0.12	soil material, middle-sand	
252	Tur Lake 9-3 Bg1(Go)		0.12 - 0.18	soil material, middle -sand	
253	Tur Lake 9-3 Bg2(Gr)		0.18 - 0.7	soil material, middle - sand	
254	Tur Lake 9-4 O (Hn)	0.3	0 - 0.1	soil surface material, moos	
255	Tur Lake 9-4 Bg2(Gr)		0.12 - 0.2	soil material, fine-sand	
256	Tur Lake 10-1			sand	
257	Tur Lake 10-2			sand	
258	Tur Lake 10-3			sand	
259	Tur Lake 10-4			sand	
260	T 027 Ah1(Ah)	0.65	0 - 0.04	soil material, fine-sand	
261	T 027 Bjj(MCv)		0.04 - 0.1	soil material, middle-sand	
262	T 027 Ah2jj(fAh)		0.1 - 0.18	soil material, fine-sand	
263	T 027 Bw1(Cv1)		0.18 - 0.4	soil material, middle-sand	
264	T 027 Bw2(Cv2)		0.4 - 0.65	soil material, middle-sand	
Ebe Sise Island, alas near the camp, 17./27.08.2005; N 72,97442°, E 123,75547°					
265	Ebe Mikropingo			peat	
266	T029-Mikropingo			peat	
267	TO20-2 Mikropingo				

Appendix 4-4: List of ground ice and surface water samples

no.	date	sample no.	composition	high [m]	depth [m]	collector
1	27.08.	Ebe Micropingo	texture ice (same position)		0,1	mathias
2	17.08.	T 007 Mikropingo	texture ice		0,1	lutz
3	19.08.	Ebe-2-I-1	segregation ice or ice filled cave		0,9	lutz
4	19.08.	Ebe-2-I-2	segregation ice		0,9	lutz
5	19.08.	Ebe-2-I-3	segregation ice		0,9	lutz
6	19.08.	Ebe-2-I-4	segregation ice		0,9	lutz
7	22.08.	Ebe-4-I-1	ice vein		3,2	lutz
8	22.08.	Ebe-4-I-2	ice vein		4,35	lutz
9	22.08.	Ebe-4-I-3	ice vein		4,3	lutz
10	22.08.	Ebe-4-S-10-Texture	texture ice		3	lutz
11	22.08.	Ebe-4-S-9-Texture	texture ice		2,85	lutz
12	31.08.	Ebe-5-I-1	ice wedge			Tanya
13	31.08.	Ebe-5-I-2	ice wedge			Tanya
14	31.08.	Ebe-5-1 (texture)	texture ice	3,2		Tanya
15	31.08.	Ebe-5-2 (texture)	texture ice	3,6		Tanya
16	31.08.	Ebe-5-3 (texture)	texture ice	3,9		Tanya
17	31.08.	Ebe-5-4 (texture)	texture ice	4,05		Tanya
18	31.08.	Ebe-5-5 (texture)	texture ice	4,75		Tanya
19	18.08.	Tur-1-I-1	ice wedge		3,3	lutz
20	18.08.	Tur-1-I-2	ice wedge		3,05	lutz
21	18.08.	Tur-1-I-3	ice wedge		2,95	lutz
22	18.08.	Tur-1-I-4	ice wedge		3,9	lutz
23	18.08.	Tur-1-I-5	ice wedge		2,6	lutz
24	18.08.	Tur-1-I-6	ice wedge		2,2	lutz
25	18.08.	Tur-1-I-7	ice wedge		1,6	lutz
26	18.08.	Tur-1-I-8	ice wedge		3,9	lutz
27	20.08.	Tur-1-I-9	ice wedge		3,9	lutz
28	20.08.	Tur-1-I-10	ice wedge		2,4	lutz
29	20.08.	Tur-1-I-11	ice wedge		2,4	lutz
30	20.08.	Tur-1-I-12	ice wedge		2,4	lutz
31	20.08.	Tur-1-I-13	ice wedge		2,4	lutz
32	20.08.	Tur-1-I-14	ice wedge		2,4	lutz
33	18.08.	Tur-1-2 (texture)	texture ice		4	lutz
34	18.08.	Tur-1-3 (texture)	texture ice		3,4	lutz
35	18.08.	Tur-1-4 (texture)	texture ice		3	lutz
36	18.08.	Tur-e	ice vein		surface	lutz
37	20.08.	Tur-2-1 (texture)	elementar ice vein		1,05	lutz
38	20.08.	Tur-2-2	ice wedge		1,2	lutz
39	20.08.	Tur-2-3 (texture)	texture ice		1,3	lutz
40	20.08.	Tur-2-4 (texture)	texture ice		1,38	lutz
41	20.08.	Tur-2-5 (texture)	texture ice		1,45	lutz
42	20.08.	Tur-2-6 (texture)	texture ice		1,51	lutz
43	20.08.	Tur-2-7 (texture)	texture ice		1,56	lutz
44	20.08.	Tur-2-10 (texture)	texture ice		1,95	lutz
45	23.08.	Tur-2-11 (texture)	texture ice		2,05	lutz
46	23.08.	Tur-2-13 (texture)	texture ice		2,25	lutz
47	23.08.	Tur-2-14 (texture)	texture ice		2,35	lutz
48	24.08.	Tur-2-37 (texture)	texture ice		5,75	lutz
49	24.08.	Tur-2-38 (texture)	texture ice		5,8	lutz
50	24.08.	Tur-2-39 (texture)	ice wedge		5,85	lutz

Appendix 4-4: Continuation

no.	sample date	sample no.	composition	Higth [m]	depth [m]	collector
51	26.08.	Kha-1-I-1	fracture filling			lutz
52	26.08.	Kha-2-I-1	polozatic ice		6,8	lutz
53	26.08.	Kha-2-I-2	polozatic ice		6,77	lutz
54	26.08.	Kha-2-I-3	polozatic ice		6,74	lutz
	26.08.	Kha-2-I-4	polozatic ice		7,3	lutz
55	30.08.	Kha-2-12 (texture)	texture ice		6,5	lutz
56	30.08.	Kha-2-14 (texture)	texture ice		6,9	lutz
57	30.08.	Kha-2- 16 (texture)	texture ice		7,8	lutz
58	30.08.	Kha-2-18 (texture)	texture ice		8,6	lutz
59	30.08.	Kha-2-20 (texture)	texture ice		8,2	lutz
60	30.08.	Kha-2-22 (texture)	texture ice		9,2	lutz
61	30.08.	Kha-2-23 (texture)	texture ice		9,8	lutz
62	30.08.	Kha-2-24 (texture)	texture ice		10,1	lutz
63	30.08.	Kha-2-26 (texture)	texture ice		11	lutz
64	30.08.	Kha-2-27 (texture)	texture ice		11,4	lutz
65	30.08.	Kha-2-28 (texture)	texture ice		14,5	lutz
66	30.08.	Kha-2-30 (texture)	texture ice		15,5	lutz
67	30.08.	Kha-2-31 (texture)	texture ice		16	lutz
68	30.08.	Kha-2-32 (texture)	texture ice		16,5	lutz
69	30.08.	Kha-2-33 (texture)	texture ice		16,9	lutz
70	30.08.	Kha-3-1 (texture)	texture ice		0,5	lutz
71	30.08.	Kha-3-I-1	polozatic ice		4,5	lutz
72	30.08.	Kha-3-I-2	polozatic ice		4,5	lutz
74	30.08.	Kha-3-I-3	polozatic ice		4,5	lutz
75	30.08.	Kha-3-I-4	polozatic ice		6,4	lutz
76	30.08.	Kha-3-I-5	polozatic ice		6,4	lutz
77	30.08.	Kha-3-I-6	polozatic ice		6,4	lutz
78	30.08.	Kha-3-I-7	polozatic ice		6,4	lutz
79	30.08.	Kha-3-I-8	polozatic ice		7,5	lutz
80	30.08.	Kha-3-I-9	polozatic ice		7,5	lutz
81	30.08.	Kha-3-I-10	polozatic ice		7,5	lutz
82	30.08.	Kha-3-I-11	polozatic ice		7,5	lutz
83	24.08.	Tur-Lake r2	lake water			guido
84	27.08.	North Tur Lake	lake water, 1st Lake Turakh Island			guido
85	26.08.	T 020 Tur-Lake Mikropingo	segregation ice			hugues
86	26.08.	T 020 Sediment Mikropingo	texture ice			hugues
87	31.08.	Tur-Lake 10-W 1	lake water			hugues
88	31.08.	Tur-Lake 10-W 2	lake water			hugues

Appendix 4-5: Bones collection from the expedition LENA 2005

No.	N samples	Taxon	Skeleton element	Preservation	Location type	Locality	Collector
Kurungnakh Island, Buor-Khaya locality							
1	BKh-05-O1	Rangifer tarandus	calcaneus		c	Kurungnakh Isl.., Buor-Khaya locality; outcrop	samples O1 - O3 from one individual, probably; recent ?
2	BKh-05-O2	Rangifer tarandus	astrogalus		c	Kurungnakh Isl.., Buor-Khaya locality; outcrop	
3	BKh-05-O3	Rangifer tarandus	centrotarsale		c	Kurungnakh Isl.., Buor-Khaya locality; outcrop	
4	BKh-05-O4	Mammuthus primigenius	tusk	fragment	a	In situ, large thermocircus, boundary betwen Ice Complex and lower sand	non collect
5	BKh-05-O5	Mammuthus primigenius	humerus	fragment	c	Kurungnakh Il.s., Buor-Khaya locality; outcrop	trashed
6	BKh-05-O28	Mammuthus primigenius	Mc I		c	Kurungnakh Isl.., Buor-Khaya locality; outcrop	from Meyer H.
7	BKh-05-O29	Large herbivorus mammal	costa		c	Kurungnakh I.s., Buor-Khaya locality; outcrop	from Meyer H., trashed
8	BKh-05-O30	Ovibos moschatus ?	ph II		c	Kurungnakh Is., Buor-Khaya locality; outcrop	from Meyer H.
9	BKh-05-O31	Equus caballus	pelvis	fragment, left	c	Kurungnakh Is., Buor-Khaya locality; outcrop	from Meyer H.

Appendix 4-5: Continuation

No.	N samples	Taxon	Skeleton element	Preservation	Location type	Locality	Collector
Khardang Island, Arynskaya Channel							
1	Kha-O6	Bison priscus	Mc		d	Khardang Isl., shore	
2	Kha-O7	Mammuthus primigenius	femur	proximal fragment	b	Knardang Isl., exposure, 3 m below the tundra surface	juv., C14
3	Kha-O8	Mammuthus primigenius	radius	fragment	c	Khardang Isl., outcrop	small
4	Kha-O9	Rangifer tarandus	radius	distal fragment with marrow	c	Khardang Isl., outcrop, middle part of stream	from Kunitsky V. V.
5	Kha-O10	Equus caballus	pelvis	fragment	c	Khardang Isl., outcrop	
6	Kha-O11	Rangifer tarandus	sacrum	fragment	d	Khardang Isl., shore	recent?, juv., trashed
7	Kha-O12	Large herbivorus mammal	costa	fragment	c	Khardang Isl., outcrop	trashed
8	Kha-O13	Large herbivorus mammal	limb bone	fragment	c	Khardang Isl., outcrop	from Kunitsky V.V., trashed
9	Kha-O14	Martes sp.?	mandibula with teeth	fragment	d	Khardang Isl., shore	
10	Kha-O15	Lepus sp.	tibia	distal fragment (2 pieces)	b	Khardang Isl., exposure, Ice Complex, 2 m below the tundra surface	samples O15 - O17 from one individual; juv
11	Kha-O16	Lepus sp.	calcaneus		b	Khardang Isl., exposure, Ice Complex, 2 m below the tundra surface	

Appendix 4-5: Continuation

No.	N samples	Taxon	Skeleton element	Preservation	Location type	Locality	Collector
12	Kha-O17	Lepus sp.	astrogalus?		b	Khardang Isl., exposure, Ice Complex, 2 m below the tundra surface	
13	Kha-O18	Mammuthus primigenius	fibula	fragment	c	Khardang Isl., exposure, middle part	juv.
14	Kha-O19	Rangifer tarandus	os carpale II+III		c	Khardang Isl., exposure, middle part	recent?
15	Kha-O20	Lepus sp.	ulna	fragment	c	Khardang Isl., exposure, middle part	recent?
16	Kha-O21	Lepus sp.	scapula	fragment	c	Khardang Isl., exposure, middle part	recent?, from Kunitsky V.V.
17	Kha-O22	Mammuthus primigenius ?	limb bone	fragment (2 pieces)	b	Khardang Isl., exposure, 5,5 m above river level, profile № 2; above peet, in unfrozen sediments	from Schirrmeister L.; trashed
18	Kha-O23	Equus sp.	tibia	fragment (2 pieces)	c	Khardang Isl., exposure, middle part	trashed
19	Kha-O24	Ancer albiferens	humerus ?	damaged	b	Khardang Isl., exposure, 1,2 m below the tundra surface	samples O24 - O27 from one individual; recent?; from Kunitsky V.V.
20	Kha-O25	Ancer albiferens	clavicula ?		b	Khardang Isl., exposure, 1,2 m below the tundra surface	
21	Kha-O26a	Ancer albiferens	costa		b	Khardang Isl., exposure, 1,2 m below the tundra surface	
22	Kha-O26b	Ancer albiferens	costa		b	Khardang Isl., exposure, 1,2 m below the tundra surface	
23	Kha-O27	Ancer albiferens	vertebra spine	fragment	b	Khardang Isl., exposure, 1,2 m below the tundra surface	

Appendix 4-6: Bone collection of Lena Delta Reserve Tiksi (see chapter 4.8)

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
1	LDR - O1	Bison priscus	cranium with horn cores		Lena Delta Region	Bykovsky Peninsula, Van'kina bay	Gukov A. Yu.	1996	
2	LDR - O2	Bison priscus	cranium with horn cores	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
3	LDR - O3	Mammuthus primigenius	mandible with teeth	damaged	Dmitriy Laptev Strait	Rebrova R.	Andreyuk A. N.	2003	
4	LDR - O4	Mammuthus primigenius	mandible with teeth	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Rotkin I. N.	2002	
5	LDR - O5	Mammuthus primigenius	mandible with teeth	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Dubov A. E.	2002	
6	LDR - O6	Mammuthus primigenius	tooth		Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Polyansky A. S.	2000	
7	LDR - O7	Mammuthus primigenius	tooth	damaged	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	2002	
8	LDR - O8	Bison priscus	cranium with left horn core	fragment	Yana Bay	Makar Isl., "Makar" polar station	Yarlykov Yu. A.	1985	
9	LDR - O9	Mammuthus primigenius	tooth		New Siberian Islands	New Siberian Isl., Goristy Cape	Yakshina I. A.	2002	
10	LDR - O10	Mammuthus primigenius	tooth	fragment	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Polyansky A. S.	2000	
11	LDR - O11	Ursus arctos	humerus		New Siberian Islands	Faddeevsky Isl., Blagoveshchensky Cape	Yakshina I. A.	2003	determination of Nikol'sky P. A.
12	LDR - O12	Panthera cf. spelaear	sacrum+pelvis with copulas		Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	2001	determination of Nikol'sky P. A.
13	LDR - O13	Bison priscus	cranium with horn cores	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Stryuchkov V. N.	2002	

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
14	LDR - O14	Mammuthus primigenius	mandible with milk teeth		Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Volkov S. Yu.	2002	juv., samples: O14, O15 - from one individual, probably
15	LDR - O15	Mammuthus primigenius	cranium with two milk teeth, two tusks	fragment (6 pieces of cranium and 2 pieces of milk teeth)	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Volkov S. Yu.	2002	
16	LDR - O17	Bison priscus	lower tooth (M3)			Muostakh Isl.	Larionov S. V.	1994	field № 48
17	LDR - O18	Equus sp.	femur, right	damaged	New Siberian Islands	New Siberian Isl., Rozhina Cape	Yakshina I. A.	2000	
18	LDR - O19	Equus sp.	cranium with P2-M3, C and I3	damaged	New Siberian Islands	New Siberian Isl., Rozhina Cape	Yakshina I. A.	2000	
19	LDR - O20	Bison priscus	mandible, right stem with all teeth		New Siberian Islands	New Siberian Isl., Rozhina Cape	Yakshina I. A.	2000	
20	LDR - O21	Equus sp.	mandible with right M1-M3, C and left P4-M3, C, I3		New Siberian Islands	New Siberian Isl., Rozhina Cape	Yakshina I. A.	2000	sore
21	LDR - O22	Bison priscus	thorax vertebra	damaged	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Polyansky A. S.	2000	
22	LDR - O23	Equus sp.	scapula, right	fragment	New Siberian Islands	New Siberian Isl., Rozhina Cape	Yakshina I. A.	2000	
23	LDR - O24	Equus sp.	femur, left	damaged	New Siberian Islands	New Siberian Isl., Rozhina Cape	Yakshina I. A.	2000	
24	LDR - O25	Equus sp.	radius, left	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Abramov A. A.	1996	

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No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
25	LDR - O26	Bison priscus	tibia		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2002	
26	LDR - O27	Mammuthus primigenius	thorax vertebra	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Stryuchkov V. N.	2002	
27	LDR - O28	Ovibos moschatus	cranium, male	fragment	New Siberian Islands	New Siberian Isl., Pestsoviy Cape	Yakshina I. A.	2001	
28	LDR - O29	Bison priscus	atlas		Yana Bay	Makar Isl., "Makar" polar station	Yarlykov Yu. A.	1985	
29	LDR - O30	Mammuthus primigenius	scapula, right	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2002	
30	LDR - O31	Mammuthus primigenius	mandible without teeth, right stem	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Dubov A. E.	2002	field № - 184
31	LDR - O32	Mammuthus primigenius	tibia	damaged	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Ponyavin V. N.	1987	
32	LDR - O33	Mammuthus primigenius	mandible	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2002	
33	LDR - O34	Mammuthus primigenius	mandible without teeth	fragment	Lena Delta Region	Bykovsky Peninisula, Mamontovaya Khayata	Safonov Yu. N.	2001	
34	LDR - O35	Mammuthus primigenius	mandible with right and left teeth	damaged	Dmitriy Laptev Strait	Khaptashinskiy Yar	Andreyuk A. N.	2002	
35	LDR - O36	Mammuthus primigenius	mandible without teeth, left stem	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Rotkin I. N.	2002	
36	LDR - O37	Ovibos moschatus	atlas		New Siberian Islands	New Siberian Isl., Rozhina Cape	Yakshina I. A.	2000	
37	LDR - O38	Mammuthus primigenius	scapula	damaged	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Lysak V. A.	1998	
38	LDR - O39	Mammuthus primigenius	mandible with teeth	fragment	New Siberian Islands	New Siberian Isl., Pestsoviy Cape	Yakshina I. A.	2001	
39	LDR - O40	Equus sp.	femur, right		New Siberian Islands	New Siberian Isl., Rozhina Cape	Yakshina I. A.	2000	

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No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
40	LDR - O41	Mammuthus primigenius	tibia	distal fragment	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Lysak V. A.	1998	
41	LDR - O42	Mammuthus primigenius	cranium (alveola)	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2002	
42	LDR - O43	Mammuthus primigenius	humerus	proximal fragment	New Siberian Islands	New Siberian Isl., Rozhina Cape	Yakshina I. A.	2000	
43	LDR - O44	Coelodonta antiquitatis	mandible, left stem with P4 - M3		Yana River Region	Mus-Khaya outcrop	Yakshina I. A.	2003	AMS, teeth heavily worn
44	LDR - O45	Mammuthus primigenius	scapula, right	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Dedyukin A. N.	2002	
45	LDR - O48	Equus sp.	upper tooth (M1), right		New Siberian Islands	New Siberian Isl., Rozhina Cape	Yakshina I. A.	2000	heavily worn
46	LDR - O49	Mammuthus primigenius	small bone of tarsale		Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Lysak V. A.	1998	
47	LDR - O50	Mammuthus primigenius	mandible with milk teeth		Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Volkov S. Yu.	2002	juv.
48	LDR - O51	Bison priscus	horn sheet		Yana Bay	Makar Isl., "Makar" polar station	Yarlykov Yu. A.	1985	
49	LDR - O52	Bison priscus?	metacarpate			O. M. P.			
50	LDR - O53	Mammuthus primigenius	tibia	fragment	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Lysak V. A.	1998	juv.
51	LDR - O54	Bison priscus	thorax vertebra		Yana Bay	Makar Isl., "Makar" polar station	Yarlykov Yu. A.	1985	
52	LDR - O55	Bison priscus	epistropheus		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
53	LDR - O56	Bison priscus	metacarpate						
54	LDR - O57	Mammuthus primigenius	thorax vertebra	damaged	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Lysak V. A.	1998	
55	LDR - O58	Mammuthus primigenius	lumbar vertebra	damaged	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Lysak V. A.	1998	

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No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
56	LDR - O59	Mammuthus primigenius	thorax vertebra	damaged	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Polyansky A. S.	2000	
57	LDR - O60	Mammuthus primigenius	epistropheus		Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Lysak V. A.	1998	juv.
58	LDR - O61	Mammuthus primigenius	tooth		New Siberian Islands	New Siberian Isl., Goristy Cape	Yakshina I. A.	2002	
59	LDR - O62	Mammuthus primigenius	tooth	damaged	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Lysak V. A.	1998	
60	LDR - O63	Bison priscis	thorax vertebra	damaged	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Lysak V. A.	1998	
61	LDR - O64	Mammuthus primigenius	atlas		Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Lysak V. A.	1998	
62	LDR - O65	Mammuthus primigenius	tusk		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Rotkin I. N.	2002	field № - A-102
63	LDR - O66	Mammuthus primigenius	femur	proximal fragment	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Ponyavin V. N.	1987	juv.
64	LDR - O67	Mammuthus primigenius	scapula	fragment	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Ponyavin V. N.	1987	
65	LDR - O68	Equus sp.	cranium with all teeth	damaged	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Ponyavin V. N.	1987	
66	LDR - O69	Equus sp.	mandible, right stem with M1 - M3	fragment	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Ponyavin V. N.	1987	
67	LDR - O70	Equus sp. ?	costa		Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Ponyavin V. N.	1987	
68	LDR - O139	Mammuthus primigenius	fibula	distal fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	
69	LDR - O141	Mammuthus primigenius	small lib bone	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	
70	LDR - O143	Mammuthus primigenius	metapodiale	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	

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No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
71	LDR - O144	Mammuthus primigenius	tibia	fragment, proximal articulation	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	juv.
72	LDR - O146	Mammuthus primigenius	costa	fragment	Lena Delta Region	Bykovsky PENINSULA, Mamontovaya Khayata	Sher A. V.	2001	DNA
73	LDR - O156	Mammuthus primigenius	thorax vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	strong lateral asymmetry
74	LDR - O181	Ovibos moschatus	cranium left and right teeth P4 - M3, male	damaged	New Siberian Islands	New Siberian Isl., Pestsoviy Cape	Yakshina I. A.	2001	
75	LDR - O201	Bison priscus	femur, left	distal articulation	Lena Delta Region	Sardakh-Ary Isl.	Gukov A. Yu.	1999	juv.
76	LDR - O202	Bison priscus	astrogalus		New Siberian Islands	Anzhu Spit, near Glubikoe Lake	Rizhiy S. N.	2002	
77	LDR - O203	Bison priscus	antebrachium, left		New Siberian Islands	Anzhu Spit, near Glubikoe Lake	Rizhiy S. N.	2002	
78	LDR - O204	Bison priscus	thorax vertebra	damaged	New Siberian Islands	Anzhu Spit, near Glubikoe Lake	Rizhiy S. N.	2002	
79	LDR - O205	Bison priscus	thorax vertebra	damaged	New Siberian Islands	Anzhu Spit, near Glubikoe Lake	Rizhiy S. N.	2002	
80	LDR - O206	Mammuthus primigenius	fibula	fragment, without distal articulation	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukova N. V.	2001	juv.
81	LDR - O207	Equus sp.	cervical vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	

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No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
82	LDR - O208	Equus sp.	Mt III, left		Olenek R.	left bank of Olonek R., Taimylyr vil., tundra surface	Krasovskiy S. E.	2001	
83	LDR - O209	Equus sp.	scapula	damaged	Lena Delta Region	Sobo-Sise Isl.	Klimenko A. N.	2000	
84	LDR - O210	Equus sp.	Mc III, right	proximal fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
85	LDR - O211	Rangifer tarandus	Mt III	fragment, without distal articulatio n	Lena Delta Region	Kurungnakh-Sise Isl.,	Gukov A. Yu.	2000	juv.
86	LDR - O212	Rangifer tarandus	tibia	fragment	coast of Laptev Sea	Buor-Khaya Cape	Gukov A. Yu.	1998	
87	LDR - O213	Rangifer tarandus	thorax vertebra	damaged	New Siberian Islands	Kotel'niy Isl., Medvezhiy Cape, Sannikov polar station	Rizhiy S. N.	2001	juv.
88	LDR - O214	Ovibos sp.?	metacarpate	fragment, without distal articulatio n	coast of Laptev Sea	Buor-Khaya Cape	Gukov A. Yu.	1998	
89	LDR - O215	Equus sp.	atlas	damaged	New Siberian Islands	Kotel'niy Isl., Medvezhiy Cape, Sannikov polar station	Rizhiy S. N.	2001	
90	LDR - O216	Bison priscus	cranium with fragment of left horn	fragment (2 pieces)	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Nikol'skiy P. A.	2001	field № MKh 01-8; determination of Nikol'skiy P. A.

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No.	N samples	Taxon	Skeleton element	Preservation	Region	Locality	Collector	Coll. Year	Notes
91	LDR - O217	Bison priscus	astrogalus		Lena Delta Region	Bykovsky Peninsula, east coast, Bykov Cape	Gukov A. Yu.	1995	determination of Nikol'skiy P. A.
92	LDR - O218	Bison priscus	lumbar vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, east coast, Bykov Cape	Gukov A. Yu.	1996	determination of Nikol'skiy P. A.
93	LDR - O219	Cervus elaphus	atlas	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	determination of Sher A. V.
94	LDR - O220	Bison priscus	thorax vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, east coast, Bykov Cape	Gukov A. Yu.	1997	determination of Nikol'skiy P. A.
95	LDR - O221	Bison priscus	antebrachium, left	fragment, without proximal articulation	Lena Delta Region	Kurungnakh-Sise Isl., Buor-Khaya loc.	Gukov A. Yu.	1996	determination of Nikol'skiy P. A.
96	LDR - O222	Bison priscus	tibia, right		Tiksi Bay	Razdel'niy Cape	Gukov A. Yu.	1991	determination of Nikol'skiy P. A.
97	LDR - O223	Bison priscus	humerus, left	damaged	Tiksi Bay	Razdel'niy Cape	Gukov A. Yu.	1991	determination of Nikol'skiy P. A.
98	LDR - O224	Bison priscus	pelvis, left	fragment	Tiksi Bay	Razdel'niy Cape	Gukov A. Yu.	1991	determination of Nikol'skiy P. A.
99	LDR - O225	Bison priscus	humerus, left		Tiksi Bay	Razdel'niy Cape	Gukov A. Yu.	1991	
100	LDR - O226	Rangifer tarandus	cranium with fragment of left antler	fragment	coast of Laptev Sea	Buor-Khaya Cape	Gukov A. Yu.	1990	juv.

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No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
101	LDR - O227	Rangifer tarandus ?	cranium with fragment of right antler	fragment	coast of Laptev Sea	Buor-Khaya Cape	Gukov A. Yu.	1990	
102	LDR - O228	Ovibos moschatus	cranium with horn cores		Olenek R.	Taimylyr vil.	Krasovskiy S. E.	1988	male
103	LDR - O230	Mammuthus primigenius	atlas	damaged	coast of Laptev Sea	Buor-Khaya Cape	Gukov A. Yu.	1990	
104	LDR - O231	Ovibos moschatus	cranium with left horn core	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Rizhiy S. N.	2001	female
105	LDR - O232	Mammuthus primigenius	thorax vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	samples: O156, O232, O233, O234, O235, O236, O237 - from one individuum, probably
106	LDR - O233	Mammuthus primigenius	thorax vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	
107	LDR - O234	Mammuthus primigenius	thorax vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	
108	LDR - O235	Mammuthus primigenius	thorax vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	strong asymmetry
109	LDR - O236	Mammuthus primigenius	thorax vertebra ?	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	
110	LDR - O237	Mammuthus primigenius	thorax vertebra ?	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	
111	LDR - O238	Mammuthus primigenius	cervical vertebra with copulas	damaged	Lena Delta Region	Kurungnakh-Sise Isl.	Manzyuk I. P.	2004	small

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No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
112	LDR - O239	Mammuthus primigenius	cervical vertebra with copulas	damaged	Lena Delta Region	Kurungnakh-Sise Isl.	Manzyuk I. P.	2004	small
113	LDR - O240	Mammuthus primigenius	epistropheus		Lena Delta Region	Kurungnakh-Sise Isl.	Manzyuk I. P.	2004	small
114	LDR - O241	Mammuthus primigenius	cervical vertebra with copulas		Lena Delta Region	Kurungnakh-Sise Isl.	Manzyuk I. P.	2004	samples: O238, O239, O240, O241, O242, O243 - from one individual, probably
115	LDR - O242	Mammuthus primigenius	cervical vertebra with copulas		Lena Delta Region	Kurungnakh-Sise Isl.	Manzyuk I. P.	2004	
116	LDR - O243	Mammuthus primigenius	tooth	damaged	Lena Delta Region	Kurungnakh-Sise Isl.	Manzyuk I. P.	2004	
117	LDR - O244	Mammuthus primigenius	tooth	damaged	Lena Delta Region	Dzhingylakh Isl.	Gukov A. Yu.	1998	
118	LDR - O245	Mammuthus primigenius	tooth		Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukova N. V.	2001	
119	LDR - O246	Mammuthus primigenius	tooth	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukova N. V.	2001	
120	LDR - O247	Mammuthus primigenius	tooth		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
121	LDR - O248	Mammuthus primigenius	tooth	fragment	Lena Delta Region	Bykovsky Peninsula, Koryakinskoe L.	Volkov E. D.	2001	
122	LDR - O249	Bison priscus	cranium with right horn core	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukova N. V.	2001	
123	LDR - O250	Mammuthus primigenius	humerus	proximal fragment	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1985	
124	LDR - O251	Rangifer tarandus	cranium	fragment	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1985	juv.

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No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
125	LDR - O252	Equus sp.	mandible, left stem with P2 - P3	fragment	Lena Delta Region	Singir-Aryta Isl.	Polyanskiy A. S.	2000	
126	LDR - O253	Equus sp.	mandible, left stem with C, P2 - P4	fragment	Lena Delta Region	Singir-Aryta Isl.	Polyanskiy A. S.	2000	sore
127	LDR - O254	Equus sp.	cranium, maxilla left stem with P2 - M3, right stem with P4 - M3	fragment (4 pieces)	Lena Delta Region	Dzhingylakh Isl.	Gukov A. Yu.	2000	
128	LDR - O255	Mammuthus primigenius	costa	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Shalourov Cape	Sellyakhov F. V.	2002	
129	LDR - O256	Equus sp.	ulna, right	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Shalourov Cape	Sellyakhov F. V.	2002	
130	LDR - O257	Mammuthus primigenius	thorax vertebra	fragment	Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Gukov A. Yu.	1999	
131	LDR – O258	Mammuthus primigenius	metacarpal bone		Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Gukov A. Yu.	1999	
132	LDR - O259	Mammuthus primigenius	metapodium		Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Gukov A. Yu.	1999	
133	LDR - O260	Mammuthus primigenius	tooth	fragment	Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Gukov A. Yu.	1999	
134	LDR - O261	Mammuthus primigenius	costa	fragment	Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Gukov A. Yu.	1999	
135	LDR - O262	Mammuthus primigenius	costa	fragment	Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Gukov A. Yu.	1999	
136	LDR - O263	Mammuthus primigenius	1-st costa, right ?	fragment	Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Gukov A. Yu.	1999	
137	LDR - O264	Mammuthus primigenius	scapula	fragment	Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Gukov A. Yu.	1999	small, juv.?
138	LDR - O265	Equus sp.	Mt III, left		Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Gukov A. Yu.	1999	

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No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
139	LDR - O266	Mammuthus primigenius	humerus	damaged	Lena Delta Region	Dzhingylakh Isl.	Gukov A. Yu.	1998	
140	LDR - O267	Mammuthus primigenius	thorax vertebra	damaged (2 pieces)		Muostakh Isl.	Larionov S. V.	1998	juv.
141	LDR - O268	Mammuthus primigenius	scapula, left with copulas	damaged	Lena Delta Region	Malyga-Sise Isl.	Gukov A. Yu.	1998	small, samples: O268, O269 - from one individual, probably
142	LDR - O269	Mammuthus primigenius	scapula, left with copulas	2 pieces	Lena Delta Region	Malyga-Sise Isl.	Gukov A. Yu.	1998	
143	LDR - O270	Mammuthus primigenius	ulna	fragment	Lena Delta Region	Dzhangylakh Isl.	Gukov A. Yu.	1998	
144	LDR - O271	Bison priscus	cranium with horn cores	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukova N. V.	2001	
145	LDR - O272	Mammuthus primigenius	femur	proximal articulatio n		Muostakh Isl., Severniy Cape	Gukov A. Yu.	2004	juv.
146	LDR - O273	Mammuthus primigenius	mandible, symphysis	fragment		Muostakh Isl., Severniy Cape	Gukov A. Yu.	2004	
147	LDR - O274	Mammuthus primigenius	fibula	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukova N. V.	2001	
148	LDR - O275	Mammuthus primigenius	tooth	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
149	LDR - O276	Mammuthus primigenius	mandible without teeth	fragment (2 pieces)	Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Grishkina V. P.	1988	with marrow
150	LDR - O277	Mammuthus primigenius	pelvis, left part	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Yakovlev A. A.	2001	

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No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
151	LDR - O278	Mammuthus primigenius	cranium	fragment	Tiksi Bay	Razdel'niy Cape	Yarlykov Yu. A.	1986	determination of Nikol'skiy P. A.
152	LDR - O279	Mammuthus primigenius	scapula, left	damaged	Tiksi Bay	Razdel'niy Cape	Yarlykov Yu. A.	1986	small, determination of Nikol'skiy P. A.
153	LDR - O280	Mammuthus primigenius	costa	fragment	Tiksi Bay	Razdel'niy Cape	Yarlykov Yu. A.	1986	determination of Nikol'skiy P. A.
154	LDR - O281	Mammuthus primigenius	pelvis, right part	fragment	Tiksi Bay	Razdel'niy Cape	Yarlykov Yu. A.	1986	determination of Nikol'skiy P. A.
155	LDR - O282	Mammuthus primigenius	scapula	fragment	Tiksi Bay	Razdel'niy Cape	Yarlykov Yu. A.	1986	
156	LDR - O283	Mammuthus primigenius	humerus	distal fragment	Tiksi Bay	Razdel'niy Cape	Yarlykov Yu. A.	1986	
157	LDR - O284	Mammuthus primigenius	humerus	distal fragment	Tiksi Bay	Razdel'niy Cape	Yarlykov Yu. A.	1986	
158	LDR - O285	Mammuthus primigenius	humerus	fragment	Tiksi Bay	Razdel'niy Cape	Yarlykov Yu. A.	1986	juv.
159	LDR - O286	Bison priscus	femus, right	proximal fragment	Tiksi Bay	Razdel'niy Cape	Yarlykov Yu. A.	1986	
160	LDR - O287	Mammuthus primigenius	femur	distal fragment	Lena Delta Region	Bykovsky Peninsula, Ivashkina Lagoon	Gukov A. Yu.	1998	
161	LDR - O288	Mammuthus primigenius	humerus without proximal articulation	damaged	Lena Delta Region	Bykovsky Peninsula, Kolychev isthmus	Postanogov I. N.	2004	juv.
162	LDR - O289	Mammuthus primigenius	atlas	damaged		Muostakh Isl.	Larionov S. V.	1990	
163	LDR - O290	Mammuthus primigenius	epistropheus	damaged		Muostakh Isl.	Gukov A. Yu.	1998	

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
164	LDR - O291	Mammuthus primigenius	cervical vertebra	damaged		Muostakh Isl.	Gukov A. Yu.	1998	
165	LDR - O292	Mammuthus primigenius	lumbar vertebra			Muostakh Isl.	Gukov A. Yu.	1998	
166	LDR - O293	Mammuthus primigenius	humerus	fragment	Lena Delta Region	Sobo-Sise Isl.	Gukov A. Yu.	1990	juv., determination of Nikol'skiy P. A.
167	LDR - O294	Mammuthus primigenius	tibia	fragment	Lena Delta Region	Sobo-Sise Isl.	Gukov A. Yu.	1990	juv., with traces of carnivora's tooth
168	LDR - O295	Mammuthus primigenius	thorax vertebra	fragment	Lena Delta Region	Sobo-Sise Isl.	Gukov A. Yu.	1990	with traces of carnivora's tooth
169	LDR - O296	Mammuthus primigenius	vertebra	fragment	Lena Delta Region	Sobo-Sise Isl.	Gukov A. Yu.	1990	with traces of carnivora's tooth
170	LDR - O297	Mammuthus primigenius	calcaneum	fragment	Lena Delta Region	Sobo-Sise Isl.	Gukov A. Yu.	1990	with traces of carnivora's tooth
171	LDR - O298	Mammuthus primigenius	pelvis, right part	fragment	Lena Delta Region	Sobo-Sise Isl.	Gukov A. Yu.	1990	
172	LDR - O299	Mammuthus primigenius	abtebrachium		Lena Delta Region	Sobo-Sise Isl.	Gukov A. Yu.	1990	small, AMS
173	LDR - O300	Rangifer tarandus	cranium with fragment of left antler	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	
174	LDR - O301	Rangifer tarandus	antler	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
175	LDR - O302	Mammuthus primigenius	tibia	distal fragment	Lena Delta Region	Sobo-Sise Isl., Krestyakh outcrop	Gukov A. Yu.	1990	
176	LDR - O303	Rangifer tarandus	shed antler	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	
177	LDR - O304	Rangifer tarandus	thorax vertebra	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
178	LDR - O305	Equus sp.	lumbar vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
179	LDR - O306	Rangifer tarandus	scapula	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
180	LDR - O307	Rangifer tarandus	tibia	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	juv., DNA
181	LDR - O308	Rangifer tarandus	metacarpate	distal fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
182	LDR - O309	Equus sp.	pelvis, right part	fragment	Lena Delta Region	Sobo-Sise Isl.	Klimenko A. N.	2000	juv.
183	LDR - O310	Mammuthus primigenius	cranium	fragment	Lena Delta Region	Dzhingylakh Isl.	Gukov A. Yu.	1998	
184	LDR - O311	Rangifer tarandus	lumbar vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
185	LDR - O312	Mammuthus primigenius	humerus without proximal articulation	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukova N. V., Yakovlev A. A.	2001	juv., with traces of carnivora's tooth
186	LDR - O313	Mammuthus primigenius	pelvis, right part	fragment	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	2002	
187	LDR - O314	Mammuthus primigenius	humerus	damaged	Lena Delta Region	Bykovsky Peninsula, Koryakinskoe L.	Yakovlev A. A.	1988	with traces of carnivora's tooth
188	LDR - O315	Mammuthus primigenius	tibia	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Yakovlev A. A.	2001	

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
189	LDR - O316	Mammuthus primigenius	radiale		Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Yakovlev A. A.	2001	
190	LDR - O317	Mammuthus primigenius	metapodium	proximal fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Yakovlev A. A.	2001	
191	LDR - O318	Mammuthus primigenius	epistropheus	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Yakovlev A. A.	2001	
192	LDR - O319	Mammuthus primigenius	costa		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
193	LDR - O320	Mammuthus primigenius	costa	damaged (2 pieces)	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	samples: O320, O321, O322, O323, O324, O329, O330, O331, O332, O336 - from one individual, probably
194	LDR - O321	Mammuthus primigenius	costa (2 pieces)		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
195	LDR - O322	Mammuthus primigenius	costa (2 pieces)		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
196	LDR - O323	Mammuthus primigenius	costa	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
197	LDR - O324	Mammuthus primigenius	costa	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
198	LDR - O325	Mammuthus primigenius	costa without articulation		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	juv., samples: O325, O326 - from one individual, probably
199	LDR - O326	Mammuthus primigenius	costa without articulation		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
200	LDR - O327	Mammuthus primigenius	costa without articulation	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	juv.
201	LDR - O328	Mammuthus primigenius	costa without articulation		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	juv.
202	LDR - O329	Mammuthus primigenius	costa	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
203	LDR - O330	Mammuthus primigenius	costa	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
204	LDR - O331	Mammuthus primigenius	costa	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
205	LDR - O332	Mammuthus primigenius	costa	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
206	LDR - O333	Mammuthus primigenius	costa	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
207	LDR - O334	Mammuthus primigenius	costa	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
208	LDR - O335	Mammuthus primigenius	costa	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
209	LDR - O336	Mammuthus primigenius	costa	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2000	
210	LDR - O337	Mammuthus primigenius	cranium	fragment	Lena Delta Region	Muostakh Isl., Severniy Cape	Rotkin I. N.	2002	
211	LDR - O338	Mammuthus primigenius	thorax vertebra	fragment	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	juv.
212	LDR - O339	Mammuthus primigenius	thorax vertebra	fragment	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	juv.
213	LDR - O340	Equus sp.	lower tooth (M1or M2)		Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukova N. V.	2001	
214	LDR - O341	Equus sp.	astrogalus		Lena Delta Region	Dzhingylakh Isl.	Gukov A. Yu.	1998	very fresh preservation

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
215	LDR - O342	Equus sp.	ph I		Lena Delta Region	Dzhingylakh Isl.	Gukov A. Yu.	1998	rounded
216	LDR - O343	Equus sp.	humerus, left	damaged	Lena Delta Region	Dzhingylakh Isl.	Gukov A. Yu.	1998	
217	LDR - O344	Equus sp.	humerus, right		Lena Delta Region	Dzhingylakh Isl.	Gukov A. Yu.	1998	
218	LDR - O345	Equus sp.	humerus, right without proximal articulation	fragment	Lena Delta Region	Dzhingylakh Isl.	Gukov A. Yu.	1998	juv.
219	LDR - O346	Equus sp.	ulna, left		Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Efimov S. N.	1985	
220	LDR - O347	Rangifer tarandus	calcaneum		Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Efimov S. N.	1985	
221	LDR - O348	Rangifer tarandus	metacarpate	damaged	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Efimov S. N.	1985	recent?, with marrow
222	LDR - O349	Rangifer tarandus	pelvis, left part	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Efimov S. N.	1985	
223	LDR - O350	Rangifer tarandus	astrogalus		Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Efimov S. N.	1985	recent?
224	LDR - O351	Rangifer tarandus	ph I		Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Efimov S. N.	1985	
225	LDR - O352	Rangifer tarandus ?	atlas	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	
226	LDR - O353	Equus sp.	cervical vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	juv.
227	LDR - O354	Equus sp.	cervical vertebra		Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	
228	LDR - O355	Equus sp. ?	cervical vertebra	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
229	LDR - O356	Equus sp.	humerus, right		Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	
230	LDR - O357	Equus sp.	humerus, right	distal fragment (2 pieces)	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	juv., very fresh preservation
231	LDR - O358	Equus sp.	tibia, right	distal fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	
232	LDR - O359	Equus sp.	lumbar vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	
233	LDR - O360	Rangifer tarandus	femur, left	distal fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	
234	LDR - O361	Rangifer tarandus	thorax vertebra	fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	
235	LDR - O362	Rangifer tarandus	radius, left	proximal fragment	Lena Delta Region	Bykovsky Peninsula, Muostakh Cape	Gukov A. Yu.	1998	juv.
236	LDR - O363	Equus sp.	femur, left	fragment	Lena Delta Region	Bykovsky Peninsula, Koryakinskoe L.	Sizintsev I. P.	1988	
237	LDR - O364	Equus sp.	femur, left	fragment	Lena Delta Region	Bykovsky Peninsula, Koryakinskoe L.	Sizintsev I. P.	1988	juv.
238	LDR - O365	Mammuthus primigenius	femur	fragment	Lena Delta Region	Bykovsky Peninsula, Koryakinskoe L.	Sizintsev I. P.	1988	juv.
239	LDR - O366	Mammuthus primigenius	ulna	damaged	Lena Delta Region	Bykovsky Peninsula, Omulyakh Lagoon	Semivelichenk o V. A.	2002	juv.
240	LDR - O367	Mammuthus primigenius	thorax vertebra	fragment	Lena Delta Region	Bykovsky P., Razdel'ny Cape	Yarlykov Yu. A.	1988	
241	LDR - O368	Bison priscus	horn sheet	fragment	Lena Delta Region	Bykovsky Peninsula, Razdel'ny Cape	Yarlykov Yu. A.	1988	
242	LDR - O369	Rangifer tarandus	mandible, left stem with dP2-dP4, M1-M3	fragment	Lena Delta Region	Sardakh-Ary Isl.	Polyanskiy A. S.	2000	juv.

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
243	LDR - O370	Equus sp.	radius, left	damaged	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
244	LDR - O371	Equus sp.	pelvis, left part	fragment	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
245	LDR - O372	Equus sp.	tibia, left		Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
246	LDR - O373	Equus sp.	scapula, left	damaged	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
247	LDR - O374	Equus sp.	scapula, right	damaged	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	very fresh preservation
248	LDR - O375	Rangifer tarandus	pelvis	fragment	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
249	LDR - O376	Bison priscus	lumbar vertebra	damaged	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
250	LDR - O377	Mammuthus primigenius	radius	fragment	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	2000	
251	LDR - O378	Bison priscus	cervical vertebra	damaged	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	2000	
252	LDR - O379	Bison priscus	cervical vertebra	damaged (3 pieces)	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
253	LDR - O380	Bison priscus	cervical vertebra	damaged (2 pieces)	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
254	LDR - O381	Bison priscus	cervical vertebra	damaged	Lena Delta Region	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
255	LDR - O382	Ursus arctos?	femur, right	damaged	Дельта р. Лена	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
256	LDR - O383	Equus sp.	Mt III, left		Дельта р. Лена	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
257	LDR - O384	Equus sp. ?	sacrum	damaged	Дельта р. Лена	Kurungnakh-Sise Isl.	Gukov A. Yu.	1998	
258	LDR - O385	Equus sp.	femur, left	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Shalourov Cape	Rizhiy S. N.	2004	

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
259	LDR - O386	Bison priscus	small bone of carpus	damaged	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Shalourov Cape	Rizhiy S. N.	2004	
260	LDR - O387	Rangifer tarandus ?	atlas	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Shalourov Cape	Rizhiy S. N.	2004	
261	LDR - O388	Rangifer tarandus	ph I		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Shalourov Cape	Natyaganchuk V. V.	1989	
262	LDR - O389	Mammuthus primigenius	1-st costa, right	fragment	New Siberian Islands	Bol'shoy Lyakhovsky Isl., Shalourov Cape	Natyaganchuk V. V.	1989	
263	LDR - O390	Mammuthus primigenius	sternum	fragment	Lena Delta Region	Gusinaya Channel	Dormidontov V. M.	1999	
264	LDR - O391	Mammuthus primigenius	costa	fragment	Lena Delta Region	Arynskaya Channel	Dormidontov V. M.	1999	
265	LDR - O392	Mammuthus primigenius	vertebra	fragment	Lena Delta Region	Tumatskaya Channel	Musiy G. A.	1999	juv.
266	LDR - O393	Mammuthus primigenius	vertebra	fragment		Tit-Ary Isl.	Solov'ev S. A.	1997	juv.
267	LDR - O394	Bison priscus	thorax	fragment	Lena Delta Region	Khardang-Sise Isl.	Gukov A. Yu.	2000	
268	LDR - O395	Ovibos moschatus	cranium with horn cores	damaged	coast of Laptev Sea	Buor-Khaya Cape	Gukov A. Yu.	1990	female
269	LDR - O420	Bison priscus	femur, left	distal fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
270	LDR - O422	Bison priscus	ph II		Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
271	LDR - O423	Bison priscus	ph II		Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
272	LDR - O424	Bison priscus ?	metapodiale	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
273	LDR - O449	Bison priscus	atlas	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
274	LDR - O450	Bison priscus	cervical vertebra		Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
275	LDR - O451	Bison priscus	cervical vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
276	LDR - O453	Bison priscus	thorax vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
277	LDR - O454	Bison priscus	thorax vertebra	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	
278	LDR - O455	Bison priscus	thorax vertebra		Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
279	LDR - O456	Bison priscus	lumbar vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
280	LDR - O457	Bison priscus	lumbar vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
281	LDR - O458	Bison priscus	lumbar vertebra	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
282	LDR - O461	Bison priscus	mandible, right stem	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
283	LDR - O462	Bison priscus	humerus, left	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
284	LDR - O463	Bison priscus	humerus, right	distal fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
285	LDR - O464	Bison priscus	pelvis, left	fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
286	LDR - O465	Bison priscus	tibia, right	damaged	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA
287	LDR - O466	? Bison priscus or Ovibos moschatus ?	tibia, left	distal fragment	Lena Delta Region	Bykovsky Peninsula, Mamontovaya Khayata	Sher A. V.	2001	DNA

Appendix 4-6: Continuation

No.	N samples	Taxon	Skeleton element	Preserva-tion	Region	Locality	Collector	Coll. Year	Notes
288	LDR - P16	Mammuthus primigenius	hair		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Sellyakhov F. V.	2002	
289	LDR - P229	Mammuthus primigenius	hair		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Zimov'e R.	Yakshina I. A.	2000	
290	LDR -P71	Coelodonta antiquitatis	hair		Olenek Region	Taimylyr village	Krasovskaya T. D.	2002	AMS
291	LDR -P72	Mammuthus primigenius	hair		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Eterikan R.	Sellyakhov F. V.	2000	AMS
292	LDR -P73	Mammuthus primigenius	hair		New Siberian Islands	Bol'shoy Lyakhovsky Isl., Shalourov Cape	Mikolauskas I.	2001	AMS

5. Studies on Holocene permafrost in the Central Lena Delta

Hanno Meyer, Alexander Dereviagin

5.1 Introduction

The Holocene history of the Lena Delta is still insufficiently understood with regard to the development of channels and of permafrost when the delta reached its current position after the last marine transgression about 5 ka BP (Grigoriev, 1993). The development of Lena Delta in Holocene occurred under the complicated paleogeographical and geocryological conditions of climate warming, marine transgression, active tectonic movements and permafrost genesis including ice wedge and pingo formation. Several Radiocarbon dates are known from the first terrace of the Lena Delta with one exception all dated to the second half of the Holocene (Schwamborn et al. 2002, Pavlova et al. 1999).

During the numerous Russian-German expeditions in the frame of Lena projects, new information on geological-geomorphological structures and Holocene Delta history were obtained (Pavlova et al. 2002, Schwamborn et al. 2002, 2004). Based on this data, our studies of Holocene permafrost deposits in Lena Delta focus on two main aims:

- First to better understand the Holocene sedimentological and especially cryolithological history of the Delta.
- Second to use the isotopic composition of ground ice as palaeo-climate indicator in highest possible resolution.

The ground ice contains information of past atmospheric precipitation, which left an almost unaltered signal stored in the permafrost: its oxygen and hydrogen isotopic compositions. The isotopic composition of ice wedges i.e. can be related to winter precipitation and, thus, reflect winter temperatures of the time of ground ice formation. Therefore, a detailed radiocarbon-based study on the stable isotopic composition of Late Holocene ice wedges is supposed reveal the winter climate history of the last 4,000 to 5,000 years. This would be the first high-resolution (50 years) winter temperature record based on a real winter temperature proxy in areas, where in general in the Arctic only summer proxies (bioindicators) are available as climate indicators.

During the expedition 2005, the history of the first terrace was studied in the Central Lena Delta. The station on Samoylov Island served as a logistical base for a number of one-day motorboat trips to Holocene outcrops in the surroundings of the island. 10 outcrops were visited, described and sampled in detail between 11th August and 1st September 2005, among them outcrops on Samoylov Island, along Tumatskaya and Arynskaya Channel near De Longs memorial place, Sardakhskaya Channel near Sardakh Island, Kurungnakh Island and Olenyekskaya Channel (Figure 5-1). A second expedition is planned to complete the sampled sites for localities in the Olenyekskaya and Bykovskaya Channels in 2008 in the eastern and western part of Lena Delta.

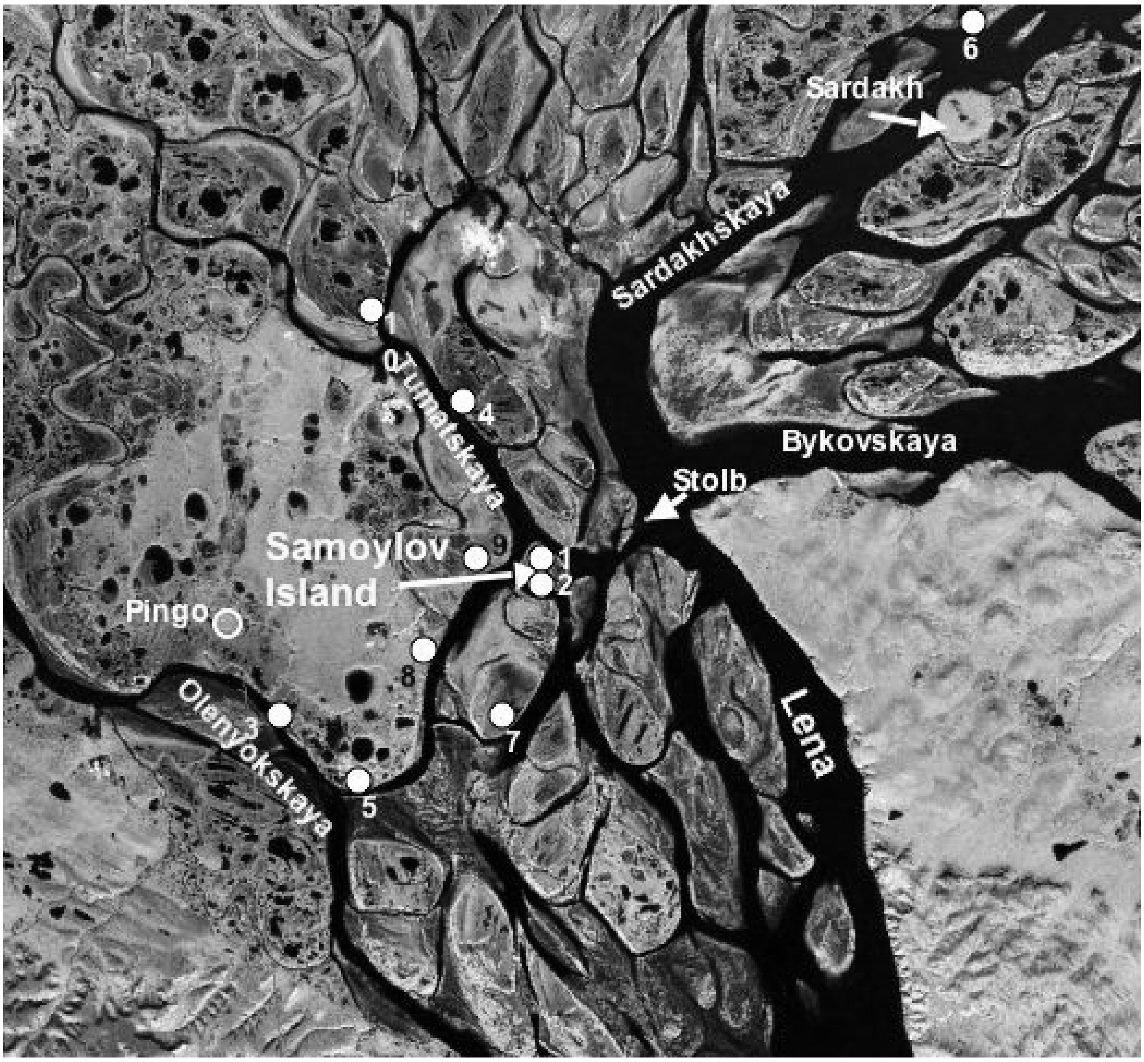

Figure 5-1: Landsat image of the Central Lena Delta including the sampled outcrops: (1) Samoylov Island site 1 (LD05-IW-1 and –2), (2) Samoylov Island site 2 (LD05-IW-3 and –4), (3) Olenyekskaya Channel site 1 (LD05-IW-5 and –6), (4) Tumatskaya Channel Site 1 (LD05-IW-7), (5) Olenyekskaya Channel site 2 (LD05-IW-8), (6) Sardakhskaya Channel (LD05-IW-9), (7) Arga Bylyr Areyta, (LD05-IW-10) (8) Kurungnakh site (LD05-IW-11), (9) Sasyl Ary site (LD05-IW-12), (10) Tumatskaya/Arynskaya Channel Site 2 (LD05-IW-13).

5.2 Outcrops

5.2.1 Outcrop 1

Samoylov Island, site 1, E facing cliff at the top of the first terrace,
two Holocene ice wedges (LD05-IW-1, LD05-IW-2)
Height: ca. 11 m above river level (a.r.l.)

The top part of the Samoylov Islands sedimentary sequence was sampled at this outcrop. The sediments include about 2.5 m of very peat-rich silty sands at the top with inclusions of thin sandy interbeds. Despite the relatively high mineral content, this unit is referred to as top peat horizon found in many places of the Island.

Description LD05-IW-1: Ice wedge LD05-IW-1 is cut perpendicularly to its frost cracking direction and reaches a width of 3.05 m at the top (max. width 3.5m). The depth of the active layer – a organic-rich sandy soil with a lot of mosses – reaches 0.45 m at this site. This ice wedge can be subdivided in a (1) about 1 m wide central part, a (2) 1 – 1.5 m lateral part and a (3) about 0.3 m wide part at both sides at the bottom of the ice wedge (Figure 5-2).

The central part of the ice wedge shows milky white to yellowish colour with mm to 0.5 cm wide single ice veins. This part is covered by a 0.8 m wide pocket of sediment, which was presumably caused by thermo-denudation due to standing or running water in the apex above the ice wedge. This assumption is likely because a nearby pond connected to the apex above ice wedge LD05-IW-1 is dry (drained by Lena River abrasion). At both sides of the central part of this ice wedge, ice of rather milky white to greyish colour is typical. At the upper right hand side of the ice wedge, a newly formed ice vein was observed in the still frozen part of the active (or transition) layer. At both sides of the bottom part, the ice wedge has brownish-coloured “shoulders”, which are connected to peat layers and ice belts in the adjacent sediment. This points to stable surface conditions at that time.

Subvertical structures are evident for the whole ice wedge. Since this ice wedge is very wide, a certain amount of time is necessary for its formation: assuming annual frost cracking (maximum hypothesis) and a maximum width of single ice veins of 0.5 cm, the minimum time interval spanned by LD05-IW-1 would be 600 years.

The sedimentary sequence of the outcrop includes very organic-rich silty sands with many ice-rich peat lenses, some with subvertically oriented roots. This is interpreted as a sign for autochthonous peat accumulation. Nonetheless, allochthonous peat accumulation cannot be ruled out. The cryostructure of the sediment is lens-like to reticulate, and some ice layers are found slightly bound upwards near ice wedges

Sampling by chain saw: Ice wedge: LD05-IW-1.1 to -1.5 (blocks), LD05-IW-1.6 to 1.28 (1.5 cm vertical slices in 10 cm intervals), LD05-IW-1.29 (contact ice wedge – sediment), LD05-IW-1.30 (recent ice vein); Sediment: LD05-S1 (near recent ice vein): 0.45 m, -S2: 1.0 m, -S3: 1.4 m below the surface.

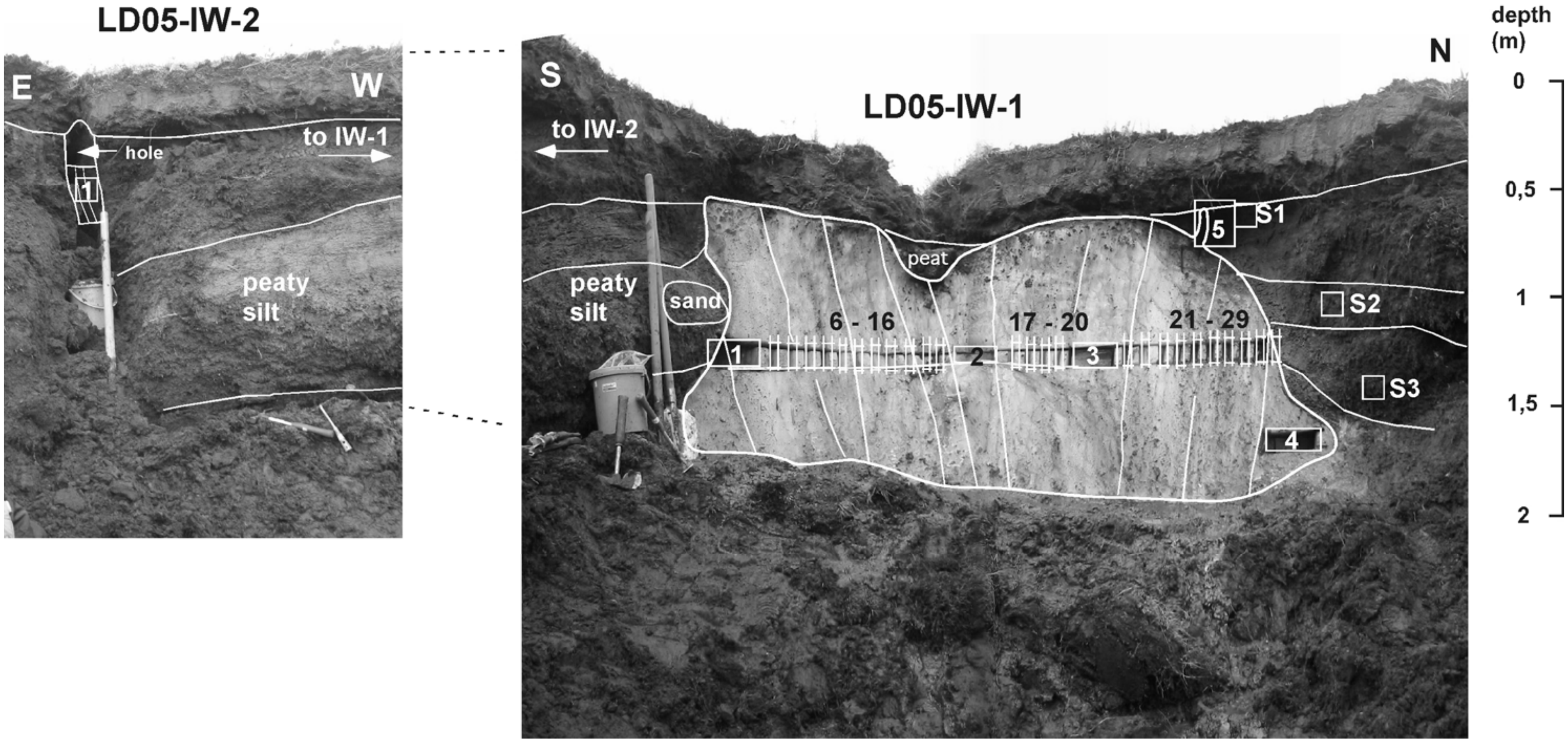

Figure 5-2: Sampling of outcrop 1 on Samoylov Island including LD05-IW-1 and LD05-IW-2

Description LD05-IW-2: Ice wedge LD05-IW-2 is located about 5 m to the SE of LD05-IW-1. It is about 0.25 m wide and cut in a right angle to its frost cracking direction. The ice wedge is related to a change in the hydrological regime, where an intrapolygonal pond was drained and the former rim of the polygon was cut by a new ice wedge generation. This ice wedge was certainly formed much later than LD05-IW-1 and most likely epigenetic to the surrounding sediments. Its upper 0.5 m have disappeared due to melting or sublimation of the ice (Figure 5-2).

Sampling by chain saw: Ice wedge: LD05-IW-2.1 (block)

5.2.2 Outcrop 2

Samoylov Island, site 2, E cliff, E facing cliff at the bottom of the first terrace, two Holocene ice wedges (LD05-IW-3, LD05-IW-4)

Height of the cliff: ca. 10 m a.r.l.; Sampling height: ca. 1 to 3.5 m a.r.l.

This outcrop comprises the whole sequence of the Samoylov Islands sediments (and ground ice). However, only the bottom part was sampled here. The sediments include about 4 m of peat at the top with inclusions of thin sand layers underlain by 2.5 m of yellowish-grey and organic-rich silty sands. Alternations of peat and sands containing ice wedges were observed between 3.5 m and 1.2 m a.r.l, These are interrupted by a prominent 0.15 m thick layer of allochthonous peat with large fragments of wood in a height of 2.5 m a.r.l., which was interpreted as “catastrophic horizon”. The lowermost meter is characterised by a yellowish sand layer with some organic or wood remains.

Description LD05-IW-3: Ice wedge LD05-IW-3 is milky-white as many Holocene ice wedges and reaches a width of 0.8 m at the top and a height of 1.5 m (Figure 5-3). A horizontal layer of most likely allochthonous peat with large wood fragments covers this ice wedge in height of 2.5 m a.r.l. Above this horizon the ice wedge LD05-IW-3 is molten and an ice wedge cast is found, at the right side laterally confined by ice layers bound upward near the former ice wedge. The wedge ice is characterised by very many gas bubbles mostly smaller than 0.5 mm, some vertically elongated and by some sand veins especially at the right hand side, where alternating ice-sand layers were observed.

Sampling by chain saw: Ice wedge LD05-IW-3.1 to 3.3 (blocks), height: 1.8 m a.r.l. Sediment: LD05-S4: 1.2 m, -S5: 1.7 m, -S6: 2.2 m, -S7: 2.7 m, -S8: 3.2 m a.r.l.

Description LD05-IW-4: This ice wedge is 3 to 5 cm wide and seems to be connected to the layer of peat at the top of this outcrop (Figure 5-3). Nonetheless, LD05-IW-4 is interrupted at the peat layer at 2.5 m a.r.l. Both above and below the “catastrophic horizon” ice wedge LD05-IW-4 is observed.

Sampling by axe: Ice wedge LD05-IW-4.1 to 4.5 (blocks)

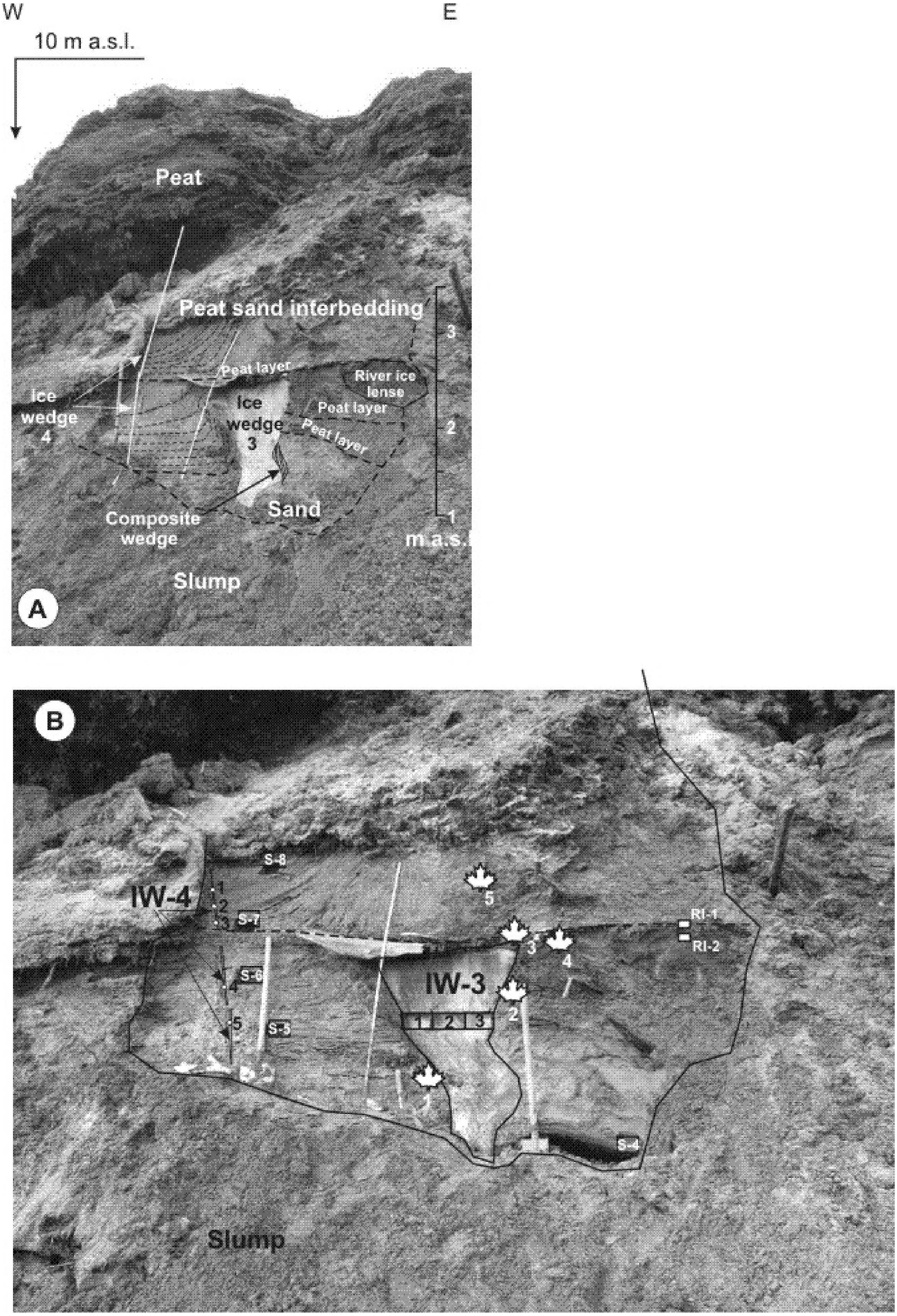

Figure 5-3: Sampling of outcrop 2 on Samoylov Island including LD05-IW-3 and LD05-IW-4

5.2.3 Geocryolithology on Samoylov Island: General impressions

Several generations of ice wedges were observed on Samoylov Island. Younger generations are associated to the peat horizon at the top of the section. Here, recent ice wedge growth occurs, evidently being are the youngest generation. The central part of ice wedge LD05-IW-1 is the youngest part in this ice wedge, with some features pointing to thermodenudation (water standing in the apex). After drainage of a nearby polygon centre, ice wedge LD05-IW-2 could form, maybe synchronously to the central part of LD05-IW-1. Towards the edge, ice wedge LD05-IW-1 gets increasingly older. The oldest section of the ice wedge is the brownish lower part.

At outcrop 2, older generations of ice wedges were found being subject to melting from the top (?) forming an ice wedge pseudomorph on top of LD05-IW-3. It is covered by a horizontal layer of most likely an allochthonous peat with large wood fragments, referred to as “catastrophic horizon" also found in other places of the Central Lena Delta. This peat layer is found at about 2.5 m a.r.l. and points to a flooding event of unknown age.

At the south coast of Samoylov Island, no ice wedges were found. Despite of that, traces of former ice wedges (such as wedge shaped holes sometimes several tens of metres in horizontal extension as well as palaeo frost cracks) indicate their former existence. Their disappearance is most likely related to sublimation of the ice and may point to the relative higher stability of the S cliff as compared the E and NE cliffs of the Island where thermo-erosion and –abrasion by Lena River are evident with large blocks fallen to the river or the much higher abundance of ice wedges.

5.2.4 Outcrop 3

Olenyekskaya Channel, site 1, SE facing cliff of the first terrace
Two Holocene ice wedges (LD05-IW-5 and IW-6)
Height of the cliff: ca. 11-12 m a.r.l.

Description LD05-IW-5: Ice wedge LD05-IW-5 is about 2.9 m wide. It is however not cut perpendicular to its growth direction, thus a smaller width of 1.8 m – 2 m seems more likely (Figure 5-4). In the height of 8 to 8.5 m a.r.l., two “shoulders” laterally confine the ice wedge; therefore above 8.5 m a.r.l., the width of the ice wedge narrows to about 1 m. The contents of sediment and organic matter in the ice wedge are relatively high, especially beneath the “shoulders” (Figure 5-4). The colour is milky-white to yellowish white as for many Holocene ice wedges rich in organic matter. The ice wedge IW-5 is embedded in dark brown to black peat with relatively low content of predominantly grey silty sediment with traces of clay and sand. The peat has been sampled in three different depths between 6.2 m and 8.0 m a.r.l.

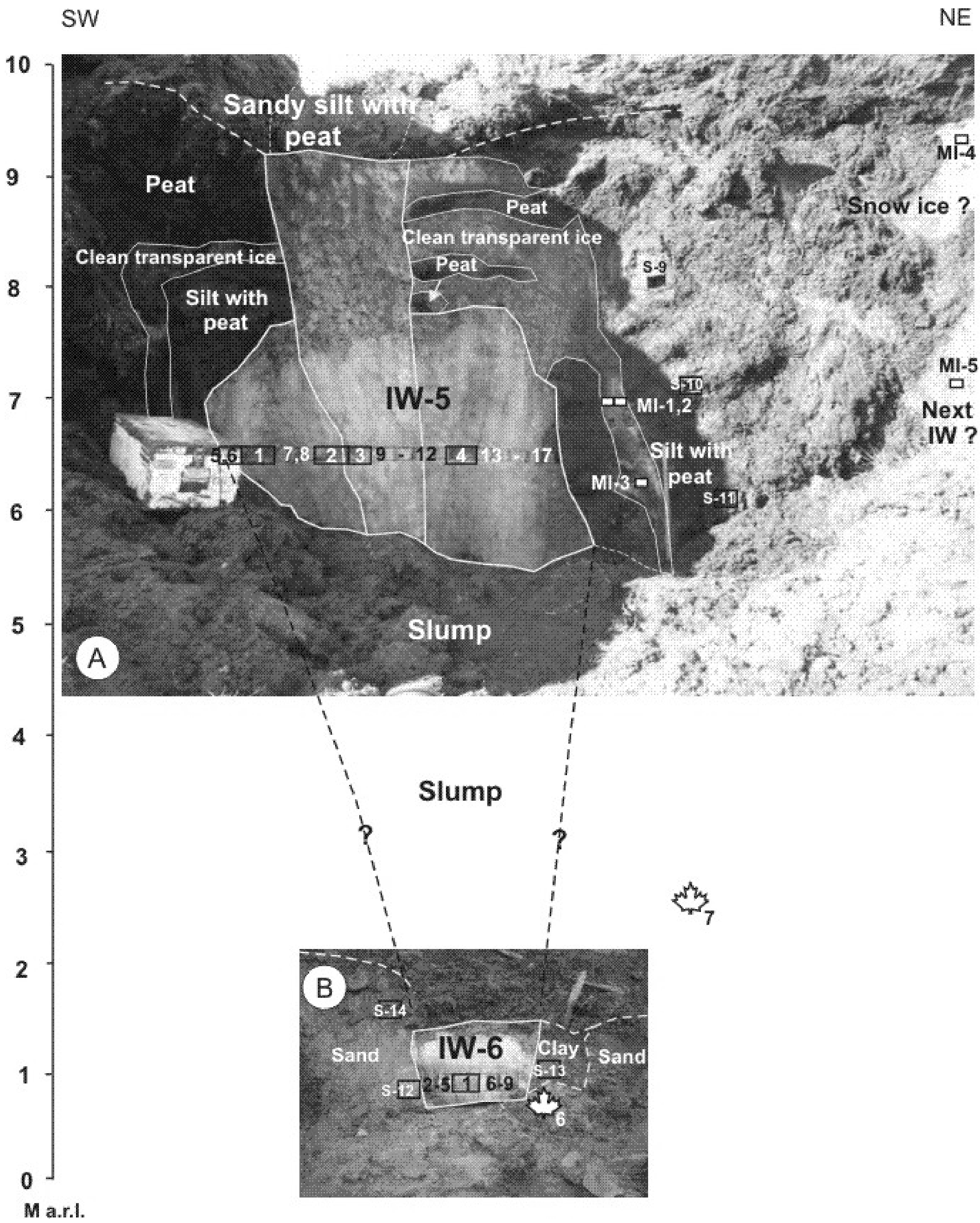

Figure 5-4: Sampling of outcrop 3 at Olenyekskaya Channel, site 1 including LD05-IW-5 and LD05-IW-6

Due to the high organic content, intrasedimental ice is very common such as lenses of pure structureless ice up to 1 m in length. A vertically oriented ice body (filling of a fissure?) has been sampled (LD05-MI-1 to MI-3) at the right side of LD05-IW-5.

Sampling by chain saw: Ice wedge LD05-IW-5.1 to 5.4 (blocks), LD05-IW-5.5 to 5.17 (1.5 cm vertical slices in 10 cm intervals), sampling height: 5.8 m a.r.l. Sediments: LD05-S9: 8.0 m, -S10: 7.1 m, -S11: 6.2 m a.r.l.

Description LD05-IW-6: Ice wedge LD05-IW-6 is situated about 5 m below IW-5 in a small outcrop near river level (Figure 5-4). It is about 0.9 m wide and about 1.1 m high and was sampled in a height of 0.3 m a.r.l., thus in the lowermost part of the first Lena terrace. It is assumed that this outcrop contains relatively old sediments and potentially old ice as well. However, the question if the outcrop 3 contains an especially old generation of ice wedges cannot be answered yet, since the top of the ice wedge IW-6 is buried under sediment debris. The contents of sediment and organic matter in the ice wedge are rather low and its colour is milky-white (Figure 5-4). Ice wedge IW-6 is laterally confined by brown to grey clay in the right side and by grey to brown silt in the left side of the ice wedge. Clay is very unusual in the Lena Delta, which is basically composed of sand and silt. Most likely a relatively deep lake with still water existed at this position permitting the deposition of clay.

Sampling by chain saw: Ice wedge LD05-IW-6.1 (block), LD05-IW-6.2 to 6.9(1.5 cm vertical slices in 10 cm intervals), sampling height: 0.3 m a.r.l. Sediments: LD05-S12: 0.4 m (silt), -S13: 0.6 m (clay), -S14: 1.5 m a.r.l (silt).

5.2.5 Outcrop 4

Tumatskaya Channel, SE facing cliff of the first terrace,
Holocene ice wedge (LD05-IW-7); sampling in three profiles
Height of the cliff: 8.5 m a.r.l.

Description LD05-IW-7: Ice wedge LD05-IW-7 is situated in a 8.5 m high cliff of the first Lena terrace. It was sampled in three different height levels between 7.5 and 2.7 m a.r.l. (Figure 5-5). The sedimentary sequence consists of peat with small wood fragments and organic-rich silt with lens-like reticulate cryostructure. At the top of the outcrop, the peat may reach a thickness of 3.5 m, thinning towards the ice wedge to about 1.5 m. The peat horizon is underlain by peaty silts and peaty sands. A 10 cm thick and most likely allochthonous peat layer containing large wood fragments was found in a height of about 2.9 m a.r.l. This peat corresponds most likely to the “catastrophic horizon” at Samoylov Island (outcrop 2). Since the ice wedge cuts this peat horizon, it must be younger than the peat (or *vice versa*, the peat is older than the ice wedge). The ice wedge LD05-IW-7 is milky-white and reaches a width of 1.4 m at the top of the outcrop. It is cut perpendicular to its growth direction and contains a lot of sediment inclusions and organic material such as lemming droppings. The diameter of the corresponding hexagonal low-centred polygons is 15 to 20 m. The upper two sampling profiles of ice wedge LD05-IW-7 belong to the same (N-S oriented) ice wedge, whereas the ice wedge of the lowermost profile (sample 7.31) has a NW-SE orientation.

Sampling by chain saw: Ice wedge LD05-IW-7; upper profile (height: 7.5 m a.r.l.) LD05-IW-7.1 (block), IW-7.2 to 7.17 (1.5 cm vertical slices in 10 cm intervals); middle profile (height: 5.2 m a.r.l.) LD05-IW-7.18 and 7.19 (blocks), IW-7.20 to 7.30 (10 cm intervals); lower profile (height: 2.7 m a.r.l.) LD05-IW-7.31 (block).

Sediments: LD05-S15: 7.9 m, -S16: 7.35 m, -S17: 6.9 m, -S18: 6.4m, -S19: 5.95 m, -S20: 5.25 m, -S21: 4.7 m, -S22: 4.1 m, -S23: 3.7, -S24: 3.2 m, -S25: 2.7 m

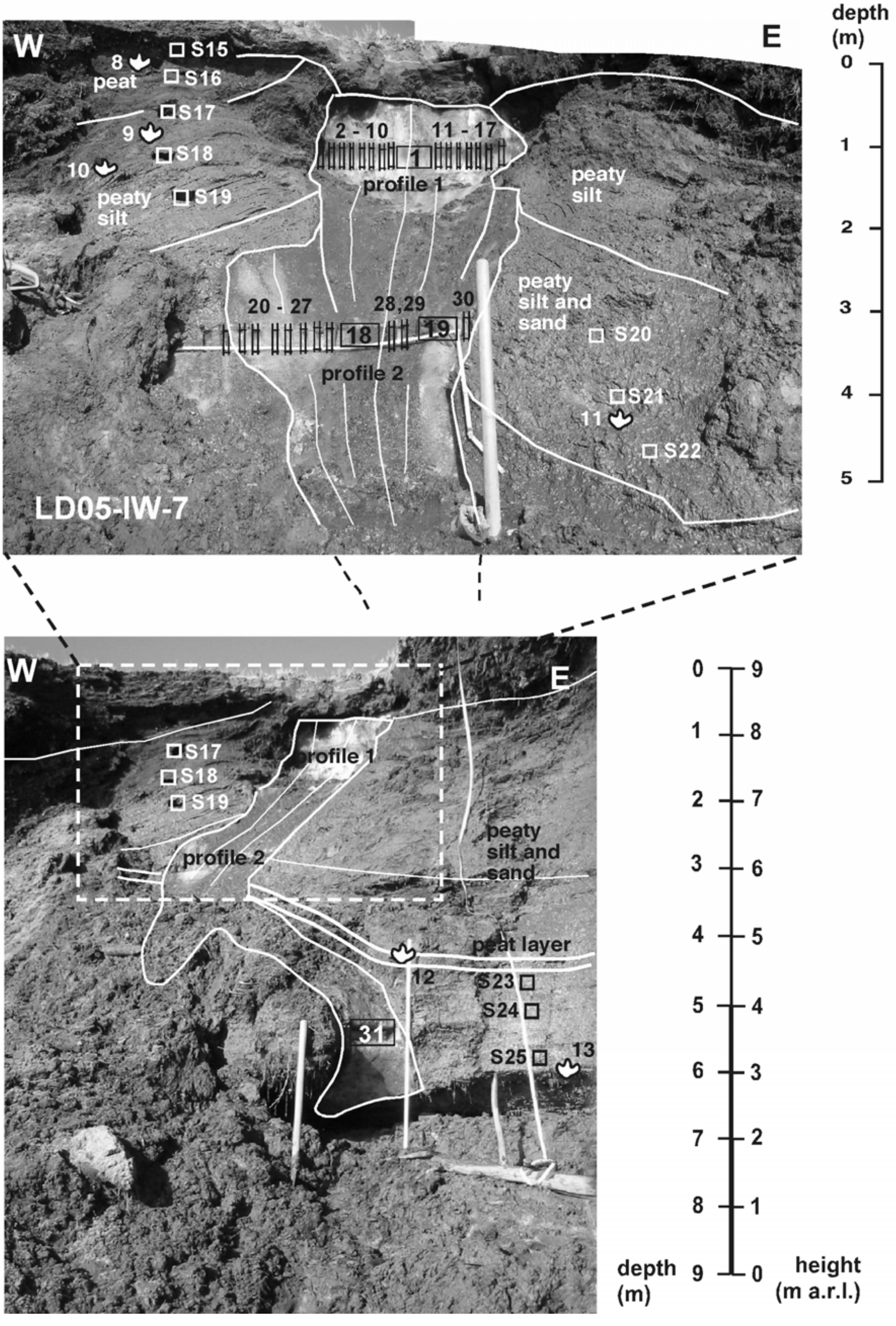

Figure 5-5: Sampling of outcrop 4, Tumatskaya Channel, site 1 including LD05-IW-7

5.2.6 Outcrop 5

Olenyekskaya Channel, S facing cliff of the first terrace,
Holocene ice wedge (LD05-IW-8)
Height of the cliff: 11 m a.r.l.

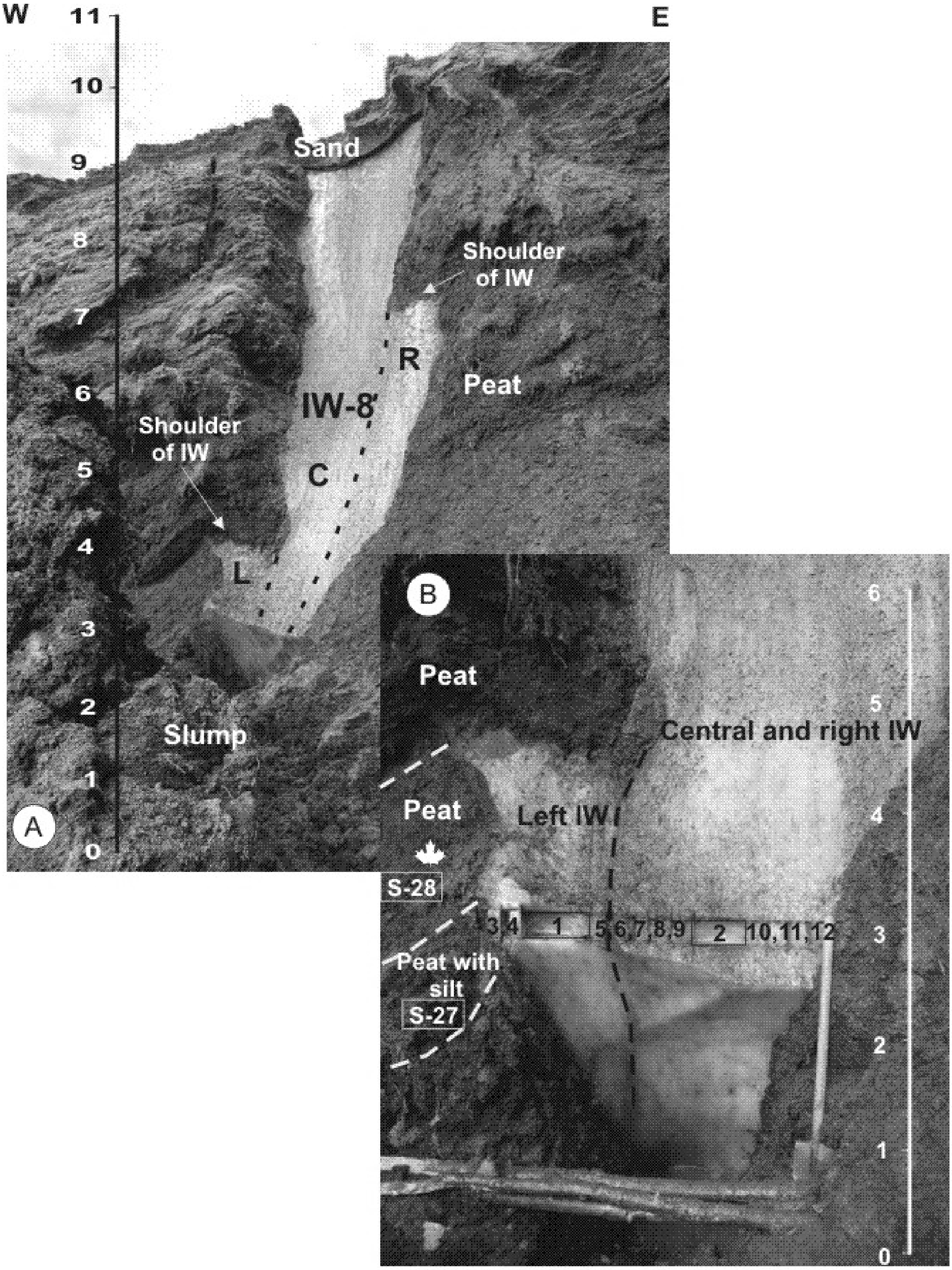

Figure 5-6: Sampling of outcrop 5 at Olenyekskaya Channel, site 2 including LD05-IW-8. A) general overview, B) sampling points. R –right side, L- left side, C-central part

Description LD05-IW-8: Ice wedge LD05-IW-8 was sampled in a 11 m high cliff of the first Lena terrace at Olenyekskaya Channel. It was sampled in a height of 2.5 m a.r.l. (Figure 5-6). The sedimentary sequence consists of 11 meters of peat with numerous roots and few wood remains, which was interpreted as a mostly likely autochthonous (?) peat. In the bottom part of the section the peat includes lenses and thin layers of gray with lens-like reticulate cryostructure. The ice wedge IW-8 is milky-white and reaches a maximum width of about 2.2 m at the top of the outcrop as well as 1.3 m width at the sampling profile. It is cut perpendicular to its growth direction and contains quite some organic and mineral inclusions. LD05-IW-8 is a high and narrow ice wedge with two well-pronounced shoulders in respective heights of 3.5 m and 6.5 m a.r.l. The ice wedge is subdivided in three vertical sections, which are related to the horizontal shoulders: the central part (C), the right part (R) and the left part (L). These parts indicate different stages of ice wedge formation. Part L is an oldest part, part C the youngest one. The height of LD05-IW-8 is more than 10 m, the horizontal extension varies from 1 to 2.2 m. It was sampled in a height of 2.5 m. The ice of ice wedge is clean, milky-white and very porous due to the inclusion of many air bubbles (1-3 mm in diameter).

Sampling by chain saw: Ice wedge LD05-IW-8.

LD05-IW-8.1 (block, part L), IW-8.2 (block, part C or R), IW-8.3 to 8.12 (1.5 cm vertical slices in 10 cm intervals)

Sediments: LD05-S26: 3.5 m, -S27: 1.5 m.

5.2.7 Outcrop 6

Gogolevsky Island, Sardakhskaya Channel, S facing cliff of the first terrace,
Holocene ice wedge (LD05-IW-9)
Height of the cliff: 7-8 m a.r.l.

Description LD05-IW-9: The cliff of the first Lena terrace is at this position 7 to 8 m high and situated on Gogolevsky Island, Sardakhskaya Channel. The sedimentological profile consists of a thick peat horizon with sandy interbeds (Figure 5-7). In the upper part of the section, the peat is relatively sandy, however sedimentological differences are rather gradual. The cryogenic structure is massive and sometimes basal. LD05-IW-9 consists of two generations of ice wedges: a thinner (1.1 m) upper ice wedge (younger ice wedge) and a thicker (older) ice wedge at the bottom, whose width can only be estimated (to about 3 m). The ice wedge system is characterised by a horizontal shoulder separating two ice facies. Ice of the upper ice wedge is dirty and grey with numerous mineral and organic inclusions. Ice of older part (under the shoulders) is milky and white, with relatively large (1-2 mm) bubbles of air and mineral inclusions (mostly sand) as well as organic remains. LD05-IW-9 was sampled in a height of 4.2 m a.r.l. At this position, the total width of the ice wedge is 2.3 m. Samples LD05-IW-9.6 to –9.14 and –9.2 are from the central part of the ice wedge system. The corresponding ice wedge polygons are degraded low centre polygons 15 m in diameter with drained intrapolygonal ponds and very wide polygon walls, which are subject sometimes to secondary cracking (at a right angle to the original frost cracking activity). Some highcentred polygons of smaller diameter (8-10 m) are found nearby. This points to a change in the original hydrological system.

The bottom part of ice wedge has been molten due to thermokarst processes and a large ice cave with an underground lake was formed. The underground lake water as well as snow remnant near the ice wedge shoulder were both sampled.

Sampling by chain saw: Ice wedge LD05-IW-9.

LD05-IW-9.1 (block, left part), IW-9.2 (block, central part), IW-9.3 to 9.19 (1.5 cm vertical slices in 10 cm intervals). Sediments: LD05-S28: 5.9 m, -S29: 5.5 m, -S30: 5.05 m, -S31: 4.25 m, -S32: 3.6 m a.r.l.

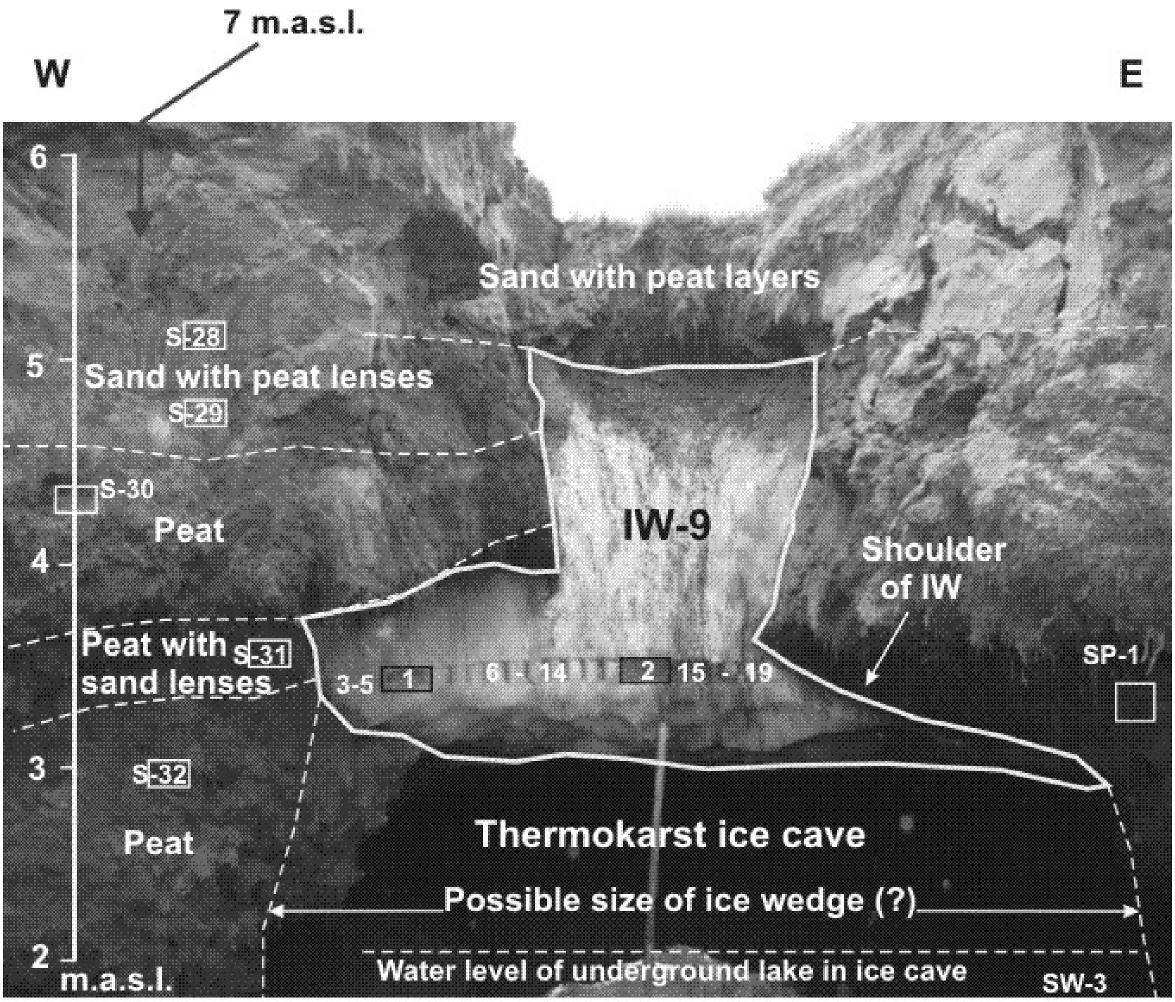

Figure 5-7: Sampling of outcrop 6, Sardakhskaya Channel including LD05-IW-9

5.2.8 Outcrop 7

Sasyl-Ary Island, Olenyekskaya Channel,
E facing cliff of the first terrace, Holocene ice wedge (LD05-IW-10)
Height of the cliff: 12 m a.r.l.

Description LD05-IW-10: Ice wedge LD05-IW-10 is situated at a 12 m high cliff of the first terrace at Sasyl-Ary Island, Olenyekskaya Channel (Figure 5-8). The geological profile is similar to outcrop 1 of Samoylov Island and consists of four main horizons all slightly bound upward near the ice wedge: (1) sand with ripple and cross-bedding structures with a few large gravel fragments in the bottom part of profile (0 - 4 m a.r.l.); (2) an allochthonous peat layer ("catastrophic horizon") with large pieces of wood (4.0 - 4.5 m), (3) peat with sand layers and lenses. In the bottom part of this layer, sand, silty sand with peat inclusions) (4.5 - 7 m a.r.l.); and a (4) thick peat horizon (7 - 11.5 m a.r.l.) with numerous large wood remains at the top of the outcrop, which let us believe that the peat was deposited (at least partly) by river action. The cryogenic texture is mostly massive. The active layer is about 0.5 to 0.6 m thick.

Ice wedge LD05-IW-10 is milky-white and most likely the intersection of two smaller ice wedges, because two main orientations of frost cracking structures were observed. The width of LD05-IW-10 is between1.4-2.0 m (1.4 m at the sampling transsect). The middle and bottom parts of LD05-IW-10 are wider than the topmost part. Ice wedge LD05-IW-10 has no well-pronounced horizontal shoulders.

Sampling by chain saw: Ice wedge LD05-IW-10.

LD05-IW-10.1 (block, 8.9 m a.r.l.), IW-10.2 (block, 6.4 m a.r.l.), IW-10.3 to 10.14 (1.5 cm vertical slices in 10 cm intervals; 8.9 m a.r.l.). Sediments: LD05-S33: 8.5 m, -S34: 4.0 m a.r.l.

5.2.9 Outcrop 8

Kurungnakh Island, Olenyekskaya Channel, E facing cliff, Holocene cover (bylar) of third Lena River terrace (Ice Complex), Holocene ice wedge (LD05-IW-11)

Height of the cliff: ca. 25 m a.r.l.

Description LD05-IW-11: Ice wedge LD05-IW-11 was sampled in a 25 m high cliff of the third Lena river terrace at Kurungnakh Island, right coast of Olenyekskaya Channel (Figure 5-9). It is located at the top of the Ice Complex between two large Late Pleistocene ice wedges and is attributed to the Holocene cover on top of the Ice Complex (bylar). It has certainly never been reached by flooding, but may not properly represent the conditions of the first terrace or might have been formed earlier.

The geological profile consists of three units: (1) ice-rich greyish silty sand (alevrit) with ice bands as well as peat lenses or pockets in the bottom part (typical Ice Complex deposits), overlain by (2) similar deposits without ice bands. Both units are dominated by lens-like reticulate cryostructure. The topmost unit (3) consists of silty sands with few peat inclusions overlain by peat with silty sands dominating the upper 2-3 m of the profile (possibly deposits of small thermokarst lakes and ponds – so called "bylar"). The thickness of active layer is about 0.3-0.4 m.

LD05-IW-11 is more than 6 m high with two well-pronounced shoulders. In the upper part it is about 2.5 m wide narrowing to about 0.3 m at the 6 m depth. The orientation is approximately 45° to the cliff, nonetheless it was sampled perpendicular to the growth direction. Subvertical structures such as up to 4 mm wide single ice veins are evident. The ice of ice wedge LD05-IW-11 is clean and white and contains very few mineral and many organic particles as well as many gas bubbles This contrasts with the adjacent Late Pleistocene ice wedges, which are much dirtier due to mineral inclusions.

Sampling by chain saw: Ice wedge: LD05-IW-11.1 (block, upper profile), IW-11.2 (block, lower profile), LD05-IW-11.3 to 11.13 (1.5 cm vertical slices in 10 cm intervals, upper profile). Lower profile: 4.8 m, Upper profile: 3.0 m below the surface.

Sediment: LD05-S35: 2.0 m, -S36: 2.8 m, -S37: 1.2 m, -S38: 3.6 m below the surface.

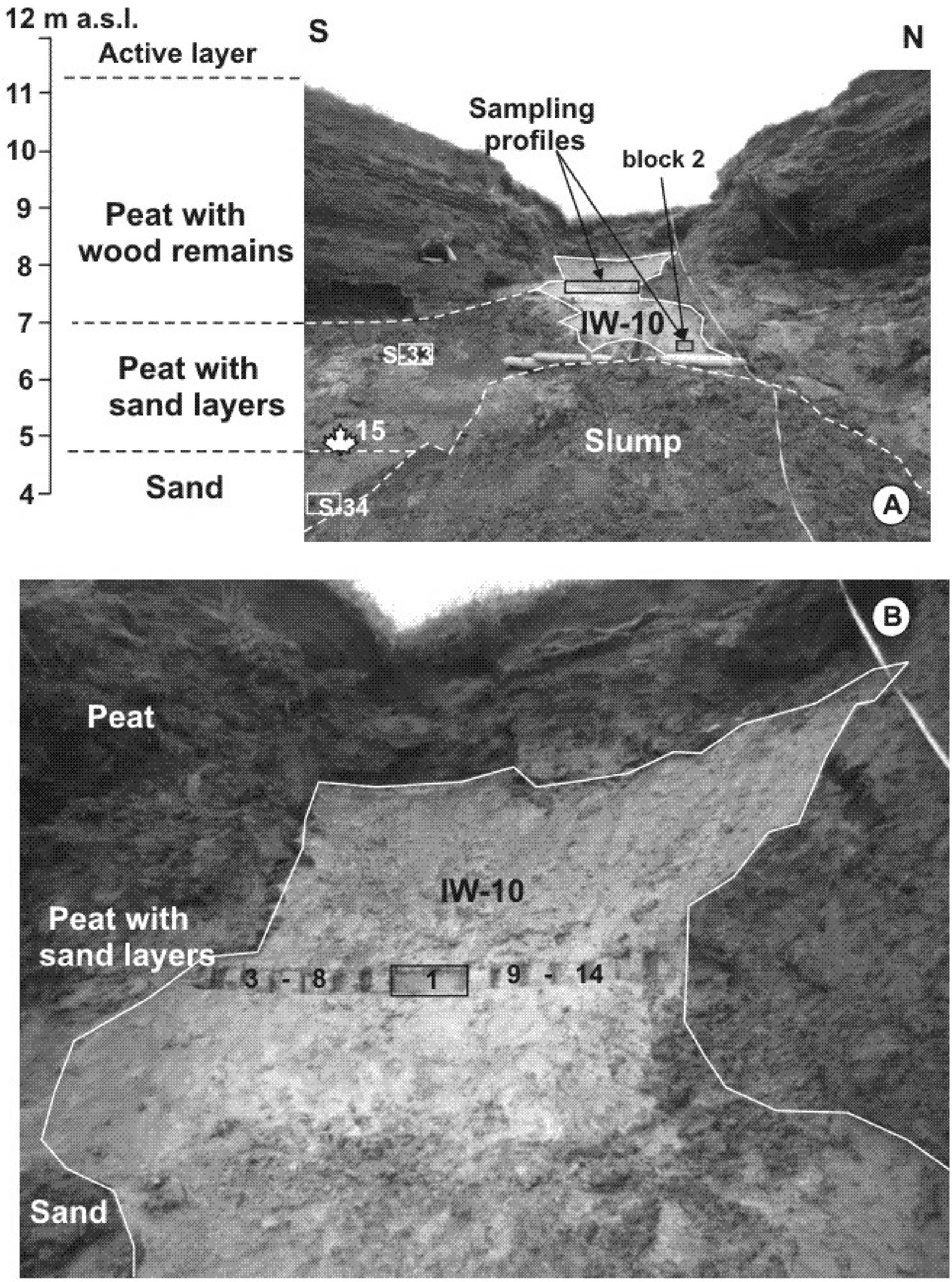

Figure 5-8: Sampling of outcrop 7 at Sasyl-Ary Island, Olenyekskaya Channel including LD05-IW-10. A general overview, B) sampling points

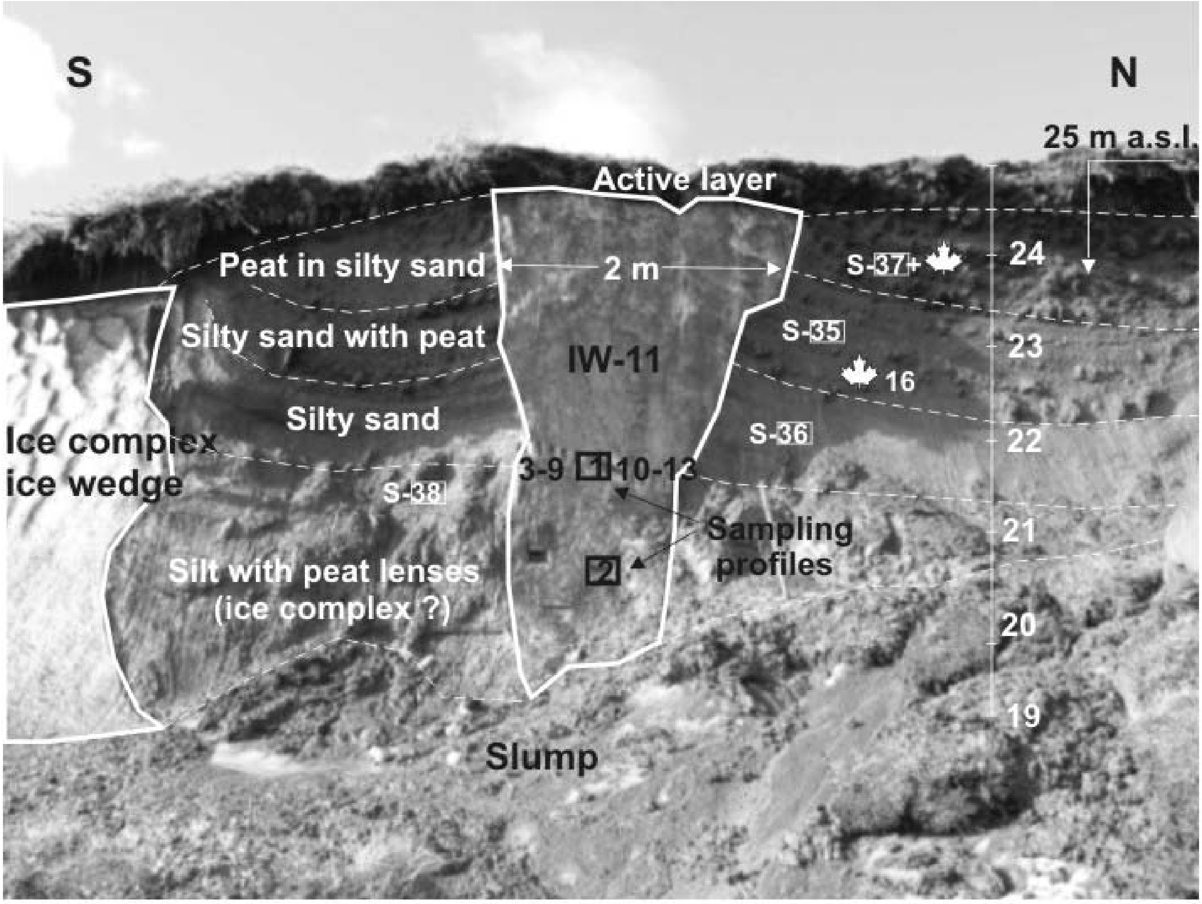

Figure 5-9: Sampling of outcrop 8, Kurungnakh Island including LD05-IW-11

5.2.10 Outcrop 9

Arga Bylyr Areita, W of Samoylov Island, E facing cliff at the top of the first terrace,
Holocene ice wedge (LD05-IW-12)
Height: 7 m above river level (a.r.l.)

Description LD05-IW-12: Ice wedge LD05-IW-12 is a Holocene ice wedge of the first terrace, most likely inactive (Figure 5-10). At the surface on top of the ice wedge, a small depression points to the possibility of degradation by flooding or standing water. It is cut perpendicularly to its frost cracking direction and reaches a maximum width of 2.4 m. The depth of the active layer, a sandy soil with a lot of organic material, reaches 0.4 m at this site. Between the active layer and the top of the ice wedge, about 1 m of peaty sands are found, containing large ice lenses of up to 1.6 m in length and 0.6 m in height (one of these has the form of an “eye of the tiger”). The ice wedge can be subdivided in a (1) about 0.3 m wide central part proceeding to the overlying peaty sand horizon, where three single ice veins are buried by peaty sands; (2) two 1 m wide lateral parts. The ice wedge is milky-white, slightly yellowish, and subvertical structures are easily recognisable. The sampling transect is 3 m below the surface, thus, 4 m above river level. At both sides, the ice wedge is confined by structureless massive ice, which may be clear transparent, milky-white or turbid yellowish-brown. These ice lenses/ massive ice bodies were sampled as MI (massive ice) -6 to MI-12. To summarise, ice wedge LD05-IW-

12 is an example for the Holocene first Lena terrace below the maximum flooding level.

Sampling by chain saw: Ice wedge: LD05-IW-12.1 (block), IW-12.2 (block), LD05-IW-12.3 to 12.24 (1.5 cm vertical slices in 10 cm intervals), LD05-IW-1.25 to –IW-27 (buried ice veins); Massive ice: MI-6 to –12. Sediment: LD05-S39: 1.1 m, -S40: 1.55 m, -S41: 2.1 m, -S41: 2.6 m below the surface.

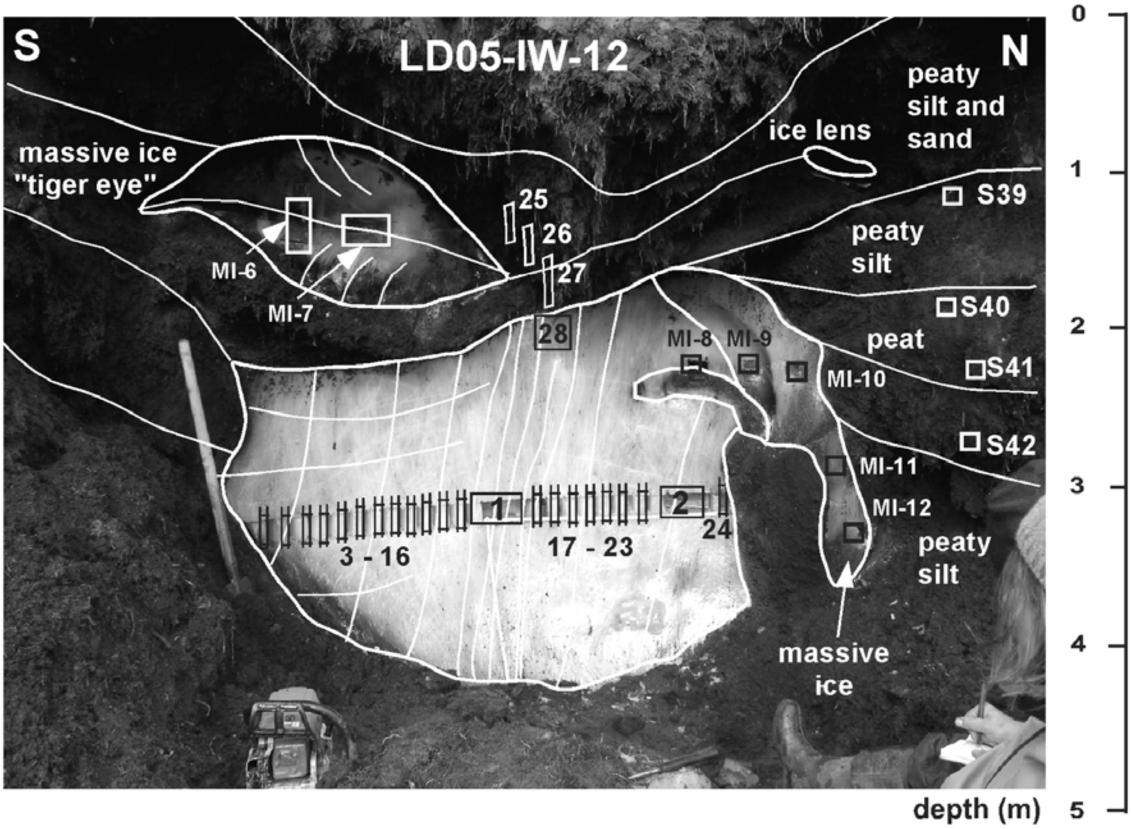

Figure 5-10: Sampling of outcrop 9, Arga Bylyr Areita Island including LD05-IW-12

5.2.11 Outcrop 10

Tumatskaya Channel near Amerika Khaya (DeLongs memorial place), SE facing cliff at the top of the first terrace,
Holocene ice wedge (LD05-IW-13)
Height: 8-9 m (a.r.l.)

Description LD05-IW-13: Ice wedge LD05-IW-13 is the northernmost outcrop of this sampling campaign and situated at Tumatskaya Channel near Amerika Khaya (Figure 5-11). The sedimentological profile consists of three main horizons: two peat horizons and an interbedding organic-rich sand horizon. The upper peat reaches a thickness of 2.5 – 3.5 m, contains many roots and sphagnum fragments, no wood remains and is, thus considered as autochthonous. The sandy horizon contains peat fragments and reaches a thickness of between 0.5 m and 1.5 m (near the ice wedge).

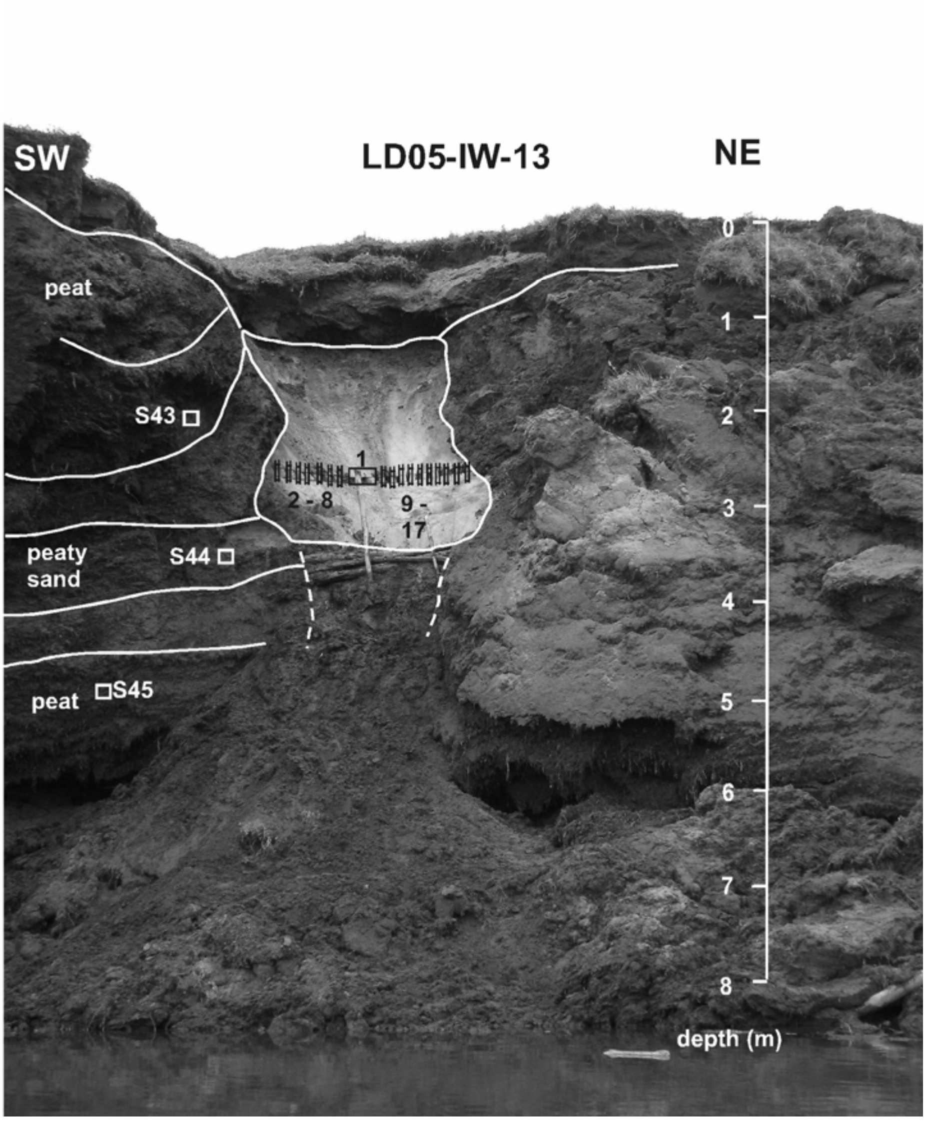

Figure 5-11: Sampling of outcrop 10, Tumatskaya Channel including LD05-IW-13.

The lower peat is about 4 m thick, black to reddish-brown, contains few roots and no wood remains and is assumed to be mostly autochthonous. Active layer thickness is 0.5 – 0.6 m. The outcrop 10 is comparable to outcrops 2 and 4. Ice wedge LD05-IW-13 is milky white to brownish, contains a lot of mineral particles (basically sand) and some organic matter. It is 1.75 m wide at the sampling transect and was sampled 3.0 m below the surface. Since the sampling was carried out at high level of Lena River, the height of the profile rather underestimated.

Sampling by chain saw: Ice wedge: LD05-IW-13.1 (block), LD05-IW-13.2 to 13.17 (1.5 cm vertical slices in 10 cm intervals), Sediment: LD05-S43: 2.6 m, -S42: 3.9 m, -S44: 5.7 m below the surface.

5.2.12 Pingo at Olenyekskaya Channel

Description of the pingo: A big pingo was found in a huge alas (thermokarst) depression at Kurungnakh Island, right coast of the Olenyekskaya Channel near outcrop 3 (Figure 5-12). The diameter of the alas depression is about 800-1000 m, which formed in ice-rich deposits of the Late Pleistocene ice complex. The net of polygons (15-25 m in diameter) characterise the floor of alas. A small lake is located at the distance of about 300-400 m from the pingo. The pingo is about 30 meters high and about 150 meters in diameter. The slopes are about 20-25° and have a rich vegetation cover of small (50 cm high) shrubs (Salix). The top of pingo is destroyed by a small thermokarst depression (4x20 m) forming a plateau-like saddle and five more elevated areas (like small domes). The north side shows signs of nival processes.

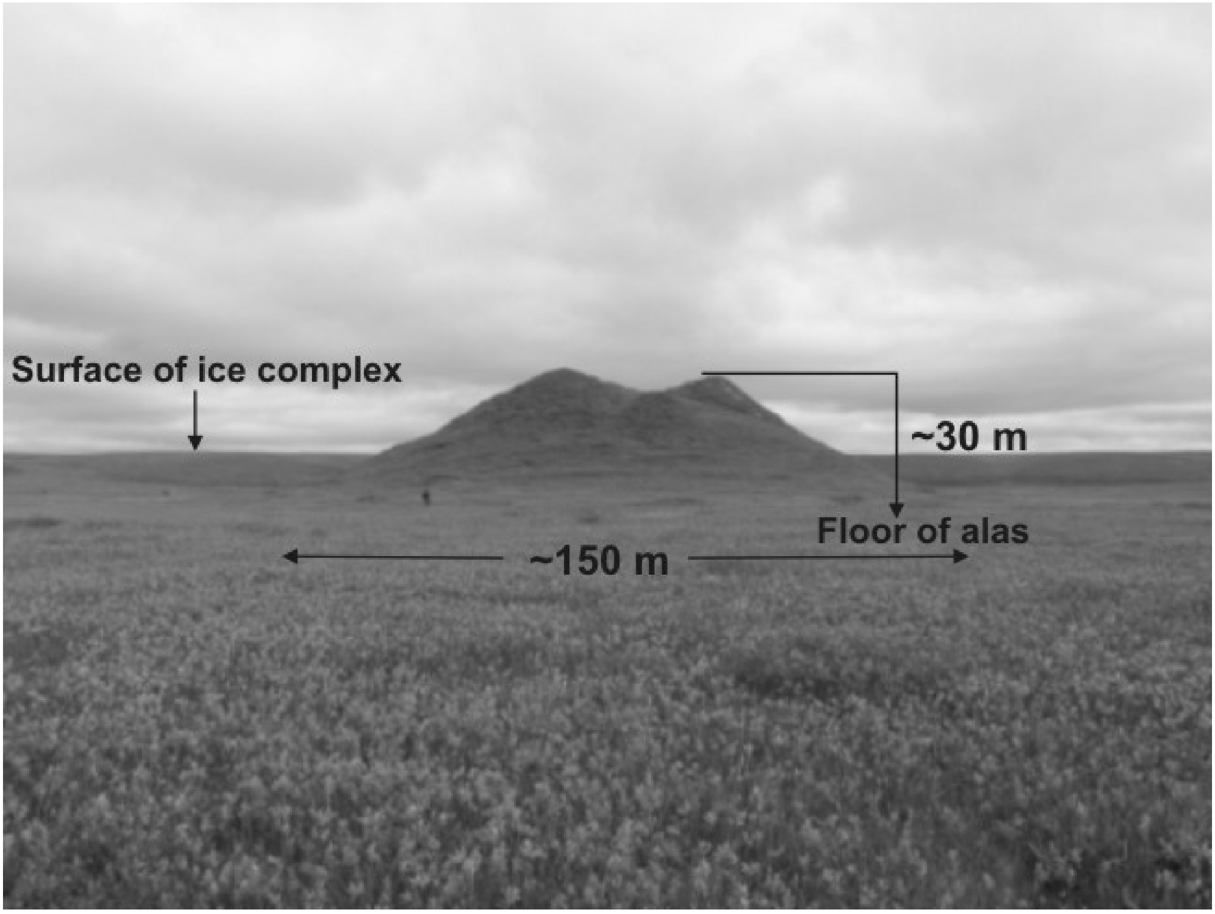

Figure 5-12: Setting of Pingo at Kurungnakh Island, right coast of Olenyekskaya Channel.

5.2.13 Summary

(1) Studying the outcrops of the first terrace in the Central Lena Delta gave new insight to the understanding of the genesis of this terrace and several new questions arose. All studied sections with ice wedges are characterised by peat horizons of different thicknesses varying between 3 m and more than 10 m. There are sections composed of organic-rich sand without covering peat horizon, which lack of ice wedges. These flood plain deposits were not tackled during this sampling campaign.

(2) It is a key question, whether the peat horizons in the sediment profiles are allochthonous (deposited by fluvial processes) or autochthonous (growing on site). For instance, larger wood fragments were certainly deposited by river activity and used as indicator for allochthonous peat deposition. The peat cover is mostly underlain by organic-rich sands. It can be assumed that main ice wedge growth started after the deposition of the (fluvial) sands, but this should be examined in further detail.

(3) Ice wedges are often characterised by shoulders, which could indicate stable surfaces (LD05-IW-8).

(4) A characteristic allochthonous peat horizon containing large pieces of wood was observed at different localities (Samoylov Island, Tumatskaya Channel) and in different height levels of the Central Lena Delta. This "catastrophic" horizon has most likely been deposited by river activity before ice wedge growth, since it is cut by ice wedges. The question is, if this deposition is a common phenomenon or a marker horizon for the Holocene Lena Delta. The "catastrophic peat" has been found between 1.8 m and 4 m a.r.l.

(5) There is an older generation of ice wedges underlying these deposits, which were found at different localities of the Central Lena Delta (Samoylov Island, Olenyekskaya Channel Tumatskaya Channel) combined with a different polygonal system. The age of this older polygonal system is unknown yet. It may occur in combination with (lacustrine?) clay (Olenyekskaya Channel), but also with peaty silts and sands (Samoylov Island).

(6) The ice wedges of the first terrace are easy to recognise because of their milky-white appearance and relatively high contents of organic matter. Since the organic matter in ice wedges can be dated by Radiocarbon, this allows us to directly date discrete pieces of ice. However, since organic matter within the ice may be derived from allochthonous or autochthonous peat, a careful selection of the samples to be dated is a prerequisite for a successful application of the ^{14}C dating method.

(7) Several signs of degradation of Holocene ice wedges systems were observed during our studies. This includes thermokarst processes e. g. by water standing above the ice wedges, thermoabrasion forming deep gullies, but also changes in the hydrological regime leading to the formation of high-centre polygons and secondary ice wedge growth.

(8) All samples taken during the field campaign LD05 including ice and water samples, sediment samples and samples of organic matter and plant are summarised in Table appendix 5-1, all sediment samples including the ice contents determined in the field can be found in Table appendix 5-2, all water samples with respective hydrochemical data (pH, conductivity) are given in Table appendix 5-3.

5.3 Studies on recent cryogenesis on Samoylov Island

The main aim of studying recent cryogenesis processes is to establish a stable isotope thermometer for ice wedges. The recent ice veins are attributed to the discrete year of their formation by means of tracer experiments. A tracer (coloured lycopodium spores) is applied to a polygon with recent cryogenesis, which allows identifying all types of ground ice, which were formed in the considered year.

Studies on recent ice wedge growth were continued for a polygon at the 1st Lena River terrace of Samoylov Island. For a detailed description of the site and the experimental set-up of the first three years, see Meyer (2003) and Meyer & Schneider (2004), Meyer and Kunitsky (2005). At the site, 10 different recent frost cracking experiments were installed. All experiments in 2005/2006 were equipped with voltage data loggers (type ESIS Minidan Volt) connected to breaking cables, which should log the moment of frost cracking.

Between 2004 and 2005, four out of ten experiments were successful and broken cables were observed. The following cables were broken: cables of experiment 2A-2B broke on 17th December, 2004; of experiment 6A-6B on 22 November, 2004 and of experiment 7A-7B cracked on 12 December, 2004. Unfortunately, loggers of experiments 4A-4B and 10A-10B failed. At experiment 5A-5B, about 10 small Cu wires were still in place, however, the experiment did not show any signs of cracking (changes of logger's voltage). At experiments 1A-1B, 3A-3B, 4A-4B, 5A-5B, 8A-8B and 9A-9B, the cables did not break. Poles to which the breaking cables are fixed were very loose, especially at those experiments, where the cables did not break,. Additionally, temperature loggers Temp-1 to Temp-4 were reinstalled to the experimental site to measure the thermal regime in the active layer on a polygon wall. Generally, the polygons were relatively wet with water standing in the polygon troughs (especially near experiment 8A-8B).

For the attribution of ice veins to the discrete year of their formation, tracer experiments were carried out. In late summer, 1 kg of **methyl orange** coloured *lycopodium* spores was applied to the polygon walls, especially to apexes above the frost crack to avoid drifting of spores by wind. In spring, when the snow cover melts, the spores should be washed into the crack. Since melt water freezes immediately, the spores are conserved in the newly formed ice vein, which can clearly be attributed to the year of its formation and then be sampled for stable isotopes.

5.4 References

Grigoriev M.N., 1993: Cryomorphogenesis of the Lena River mouth area - Yakutsk, SO AN SSSR, 176 p. (in Russian).

Meyer, H. & Kunitsky, V. V. (2006): Studies on recent cryogenesis. - In: Wagner, D. (Ed.), Russian-German Cooperation System Laptev Sea - The Expedition Lena 2004.- Reports on Polar Research **539**, p. 62-65.

Meyer, H. & Schneider, W. (2004): Studies on recent cryogenesis. - In: Schirrmeister, L. (Ed.), Expeditions in Siberia in 2003.- Reports on Polar Research **489**, p. 30-33.

Meyer, H. (2003): Studies on recent cryogenesis. - In: Grigoriev, M. N., Rachold, V., Bolshiyanov, D. Yu., Pfeiffer, E. M., Schirrmeister, L., Wagner, D., Hubberten, H.-W. (Eds.), Russian-German Cooperation System Laptev Sea - The Expedition Lena 2002.- Reports on Polar Research **466**, p. 29-48.

Pavlova E.Yu., Dorozhkina M.V. (2002) The Holocene Alluvial Delta Relief Complex and Hydrological Regime of the Lena River Delta. Polarforschung, 70: 89-100.

Pavlova, E., Dorozkhina, M., Rachold, V., (1999). Geomorphological structure of the western sector of the Lena River Delta. Terra Nostra, 99/11: Fifth Workshop on Russian–German Cooperation: Laptev Sea System, Program and Abstracts, St. Petersburg, p. 57.

Schwamborn G.J. (2004) Late Quaternary Sedimentation History of the Lena Delta. Reports on Polar and Marine Research, 471: 102 pp.

Schwamborn, G., Rachold, V., Grigoriev, M. N. (2002): Late Quaternary sedimentation history of the Lena Delta. - Quaternary International 89:119–134

5.5 Appendices chapter 5

Appendix 5-1: Ice sample list

Nr	Sample	date	type	location	sampled by	packaging
1	LD05-99/01	12.08.2005	RW	Samoylov - house	hand	bottle
2	LD05-IW-1.1	14.08.2005	IW	Samoylov - site 1	chain saw	big frozen block in plastic pocket
3	LD05-IW-1.2	14.08.2005	IW	Samoylov - site 1	chain saw	big frozen block in plastic pocket
4	LD05-IW-1.3	14.08.2005	IW	Samoylov - site 1	chain saw	big frozen block in plastic pocket
5	LD05-IW-1.4	14.08.2005	IW	Samoylov - site 1	chain saw	big frozen block in plastic pocket
6	LD05-IW-1.5	14.08.2005	RIW	Samoylov - site 1	chain saw	big frozen block in plastic pocket
7	LD05-IW-1.6	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
8	LD05-IW-1.7	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
9	LD05-IW-1.8	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
10	LD05-IW-1.9	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
11	LD05-IW-1.10	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
12	LD05-IW-1.11	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
13	LD05-IW-1.12	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
14	LD05-IW-1.13	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
15	LD05-IW-1.14	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
16	LD05-IW-1.15	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
17	LD05-IW-1.16	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
18	LD05-IW-1.17	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
19	LD05-IW-1.18	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
20	LD05-IW-1.19	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
21	LD05-IW-1.20	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
22	LD05-IW-1.21	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
23	LD05-IW-1.22	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
24	LD05-IW-1.23	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
25	LD05-IW-1.24	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
26	LD05-IW-1.25	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
27	LD05-IW-1.26	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
28	LD05-IW-1.27	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
29	LD05-IW-1.28	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
30	LD05-IW-1.29	14.08.2005	IW	Samoylov - site 1	chain saw	frozen slice in plastic pocket
31	LD05-IW-1.30	14.08.2005	RIW	Samoylov - site 1	chain saw	frozen slice in plastic pocket, bottle
32	LD05-S-1	14.08.2005	SS	Samoylov - site 1	chain saw	frozen block in plastic pocket
33	LD05-S-2	14.08.2005	SS	Samoylov - site 1	axe	frozen block in plastic pocket
34	LD05-S-3	14.08.2005	SS	Samoylov - site 1	chain saw	frozen block in plastic pocket
35	LD05-IW-2.1	14.08.2005	IW	Samoylov - site 1	chain saw	frozen block in plastic pocket
36	LD05-S-4	15.08.2005	SS	Samoylov - site 2	axe	frozen block in plastic pocket
37	LD05-S-5	15.08.2005	SS	Samoylov - site 2	chain saw	frozen block in plastic pocket
38	LD05-S-6	15.08.2005	SS	Samoylov - site 2	chain saw	frozen block in plastic pocket
39	LD05-S-7	15.08.2005	SS	Samoylov - site 2	chain saw	frozen block in plastic pocket
40	LD05-S-8	15.08.2005	SS	Samoylov - site 2	chain saw	frozen block in plastic pocket

Appendix 5-1: Continuation

Nr	Sample	date	type	location	sampled by	packaging
41	LD05-14C-1	15.08.2005	wood	Samoylov - site 2	axe	plastic pocket
42	LD05-14C-2	15.08.2005	wood	Samoylov - site 2	axe	plastic pocket
43	LD05-14C-3	15.08.2005	wood	Samoylov - site 2	axe	plastic pocket
44	LD05-14C-4	15.08.2005	peat	Samoylov - site 2	hand	plastic pocket
45	LD05-14C-5	15.08.2005	wood	Samoylov - site 2	axe	plastic pocket
46	LD05-IW-3.1	15.08.2005	IW	Samoylov - site 2	chain saw	big frozen block in plastic pocket
47	LD05-IW-3.2	15.08.2005	IW	Samoylov - site 2	chain saw	big frozen block in plastic pocket
48	LD05-IW-3.3	15.08.2005	IW	Samoylov - site 2	chain saw	big frozen block in plastic pocket
49	LD05-IW-4.1	15.08.2005	IW	Samoylov - site 2	axe	bottle
50	LD05-IW-4.2	15.08.2005	IW	Samoylov - site 2	axe	bottle
51	LD05-IW-4.3	15.08.2005	IW	Samoylov - site 2	axe	bottle
52	LD05-IW-4.4	15.08.2005	IW	Samoylov - site 2	axe	bottle
53	LD05-IW-4.5	15.08.2005	IW	Samoylov - site 2	axe	bottle
54	LD05-TI-1	15.08.2005	TI	Samoylov - site 2	chain saw	bottle (=S7)
55	LD05-RI-1	15.08.2005	RI	Samoylov - site 2	axe	bottle
56	LD05-RI-2	15.08.2005	RI	Samoylov - site 2	axe	bottle
57	LD05-99/02	16.08.2005	RW	Samoylov - house	hand	bottle
58	LD05-IW-5.1	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	big frozen block in plastic pocket
59	LD05-IW-5.2	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	big frozen block in plastic pocket
60	LD05-IW-5.3	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	big frozen block in plastic pocket
61	LD05-IW-5.4	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
62	LD05-IW-5.5	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
63	LD05-IW-5.6	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
64	LD05-IW-5.7	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
65	LD05-IW-5.8	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
66	LD05-IW-5.9	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
67	LD05-IW-5.10	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
68	LD05-IW-5.11	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
69	LD05-IW-5.12	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
70	LD05-IW-5.13	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
71	LD05-IW-5.14	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
72	LD05-IW-5.15	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket

Appendix 5-1: Continuation

Nr	Sample	date	type	location	sampled by	packaging
73	LD05-IW-5.16	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
74	LD05-IW-5.17	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
75	LD05-IW-6.1	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	big frozen block in plastic pocket
76	LD05-IW-6.2	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
77	LD05-IW-6.3	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
78	LD05-IW-6.4	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
79	LD05-IW-6.5	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
80	LD05-IW-6.6	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
81	LD05-IW-6.7	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
82	LD05-IW-6.8	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
83	LD05-IW-6.9	17.08.2005	IW	Olenyekskaya Channel - site 1	chain saw	frozen slice in plastic pocket
84	LD05-S-9	17.08.2005	SS	Olenyekskaya Channel - site 1	chain saw	frozen block in plastic pocket
85	LD05-S-10	17.08.2005	SS	Olenyekskaya Channel - site 1	chain saw	frozen block in plastic pocket
86	LD05-S-11	17.08.2005	SS	Olenyekskaya Channel - site 1	chain saw	frozen block in plastic pocket
87	LD05-S-12	17.08.2005	SS	Olenyekskaya Channel - site 1	axe	frozen block in plastic pocket
88	LD05-S-13	17.08.2005	SS	Olenyekskaya Channel - site 1	axe	frozen block in plastic pocket
89	LD05-S-14	17.08.2005	SS	Olenyekskaya Channel - site 1	axe	frozen block in plastic pocket
90	LD05-MI-1	17.08.2005	MI	Olenyekskaya Channel - site 1	chain saw	bottle
91	LD05-MI-2	17.08.2005	MI	Olenyekskaya Channel - site 1	chain saw	bottle
92	LD05-MI-3	17.08.2005	MI	Olenyekskaya Channel - site 1	chain saw	bottle
93	LD05-MI-4	17.08.2005	MI	Olenyekskaya Channel - site 1	axe	bottle
94	LD05-MI-5	17.08.2005	MI	Olenyekskaya Channel - site 1	axe	bottle
95	LD05-14C-6	17.08.2005	wood	Olenyekskaya Channel - site 1	hand	plastic pocket
96	LD05-14C-7	17.08.2005	wood	Olenyekskaya Channel - site 1	hand	plastic pocket
97	LD05-SW-1	17.08.2005	SW	Olenyekskaya Channel	hand	bottle
98	LD05-IW-7.1	18.08.2005	IW	Tumatskaya Channel site	chain saw	big frozen block in plastic pocket

Appendix 5-1: Continuation

Nr	Sample	date	type	location	sampled by	packaging
99	LD05-IW-7.2	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
100	LD05-IW-7.3	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
101	LD05-IW-7.4	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
102	LD05-IW-7.5	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
103	LD05-IW-7.6	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
104	LD05-IW-7.7	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
105	LD05-IW-7.8	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
106	LD05-IW-7.9	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
107	LD05-IW-7.10	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
108	LD05-IW-7.11	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
109	LD05-IW-7.12	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
110	LD05-IW-7.13	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
111	LD05-IW-7.14	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
112	LD05-IW-7.15	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
113	LD05-IW-7.16	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
114	LD05-IW-7.17	18.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
115	LD05-S-15	18.08.2005	SS	Tumatskaya Channel site	chain saw	frozen block in plastic pocket
116	LD05-S-16	18.08.2005	SS	Tumatskaya Channel site	chain saw	frozen block in plastic pocket
117	LD05-S-17	18.08.2005	SS	Tumatskaya Channel site	chain saw	frozen block in plastic pocket
118	LD05-S-18	19.08.2005	SS	Tumatskaya Channel site	chain saw	frozen block in plastic pocket
119	LD05-S-19	19.08.2005	SS	Tumatskaya Channel site	chain saw	frozen block in plastic pocket
120	LD05-S-20	19.08.2005	SS	Tumatskaya Channel site	axe	frozen block in plastic pocket
121	LD05-S-21	19.08.2005	SS	Tumatskaya Channel site	axe	frozen block in plastic pocket
122	LD05-S-22	19.08.2005	SS	Tumatskaya Channel site	axe	frozen block in plastic pocket
123	LD05-S-23	19.08.2005	SS	Tumatskaya Channel site	axe	frozen block in plastic pocket
124	LD05-S-24	19.08.2005	SS	Tumatskaya Channel site	axe	frozen block in plastic pocket
125	LD05-S-25	19.08.2005	SS	Tumatskaya Channel site	axe	frozen block in plastic pocket

Appendix 5-1: Continuation

Nr	Sample	date	type	location	sampled by	packaging
126	LD05-IW-7.18	19.08.2005	IW	Tumatskaya Channel site	chain saw	big frozen block in plastic pocket
127	LD05-IW-7.19	19.08.2005	IW	Tumatskaya Channel site	chain saw	big frozen block in plastic pocket
128	LD05-IW-7.20	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
129	LD05-IW-7.21	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
130	LD05-IW-7.22	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
131	LD05-IW-7.23	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
132	LD05-IW-7.24	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
133	LD05-IW-7.25	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
134	LD05-IW-7.26	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
135	LD05-IW-7.27	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
136	LD05-IW-7.28	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
137	LD05-IW-7.29	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
138	LD05-IW-7.30	19.08.2005	IW	Tumatskaya Channel site	chain saw	frozen slice in plastic pocket
139	LD05-IW-7.31	19.08.2005	IW	Tumatskaya Channel site	chain saw	big frozen block in plastic pocket
140	LD05-14C-8	19.08.2005	peat	Tumatskaya Channel site	hand	plastic pocket
141	LD05-14C-9	19.08.2005	peat	Tumatskaya Channel site	hand	plastic pocket
142	LD05-14C-10	19.08.2005	wood	Tumatskaya Channel site	hand	plastic pocket
143	LD05-14C-11	19.08.2005	wood	Tumatskaya Channel site	hand	plastic pocket
144	LD05-14C-12	19.08.2005	wood	Tumatskaya Channel site	hand	plastic pocket
145	LD05-14C-13	19.08.2005	peat	Tumatskaya Channel site	hand	plastic pocket
146	LD05-SW-2	19.08.2005	SW	Tumatskaya Channel	hand	bottle
147	LD05-IW-8.1	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	big frozen block in plastic pocket
148	LD05-IW-8.2	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	big frozen block in plastic pocket
149	LD05-IW-8.3	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	frozen slice in plastic pocket
150	LD05-IW-8.4	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	frozen slice in plastic pocket
151	LD05-IW-8.5	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	frozen slice in plastic pocket

Appendix 5-1: Continuation

Nr	Sample	date	type	location	sampled by	packaging
152	LD05-IW-8.6	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	frozen slice in plastic pocket
153	LD05-IW-8.7	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	frozen slice in plastic pocket
154	LD05-IW-8.8	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	frozen slice in plastic pocket
155	LD05-IW-8.9	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	frozen slice in plastic pocket
156	LD05-IW-8.10	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	frozen slice in plastic pocket
157	LD05-IW-8.11	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	frozen slice in plastic pocket
158	LD05-IW-8.12	20.08.2005	IW	Olenyekskaya Channel - site 2	chain saw	frozen slice in plastic pocket
159	LD05-S-26	20.08.2005	SS	Olenyekskaya Channel - site 2	axe	frozen block in plastic pocket
160	LD05-S-27	20.08.2005	SS	Olenyekskaya Channel - site 2	chain saw	frozen block in plastic pocket
161	LD05-99/03	21.08.2005	RW	Samoylov	hand	bottle
162	LD05-IW-9.1	23.08.2005	IW	Sardakhsky Channel site	chain saw	big frozen block in plastic pocket
163	LD05-IW-9.2	23.08.2005	IW	Sardakhsky Channel site	chain saw	big frozen block in plastic pocket
164	LD05-IW-9.3	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
165	LD05-IW-9.4	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
166	LD05-IW-9.5	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
167	LD05-IW-9.6	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
168	LD05-IW-9.7	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
169	LD05-IW-9.8	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
170	LD05-IW-9.9	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
171	LD05-IW-9.10	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
172	LD05-IW-9.11	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
173	LD05-IW-9.12	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
174	LD05-IW-9.13	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
175	LD05-IW-9.14	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
176	LD05-IW-9.15	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
177	LD05-IW-9.16	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
178	LD05-IW-9.17	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket

Appendix 5-1: Continuation

Nr	Sample	date	type	location	sampled by	packaging
179	LD05-IW-9.18	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
180	LD05-IW-9.19	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
181	LD05-IW-9.20	23.08.2005	IW	Sardakhsky Channel site	chain saw	frozen slice in plastic pocket
182	LD05-S-28	23.08.2005	SS	Sardakhsky Channel site	axe	frozen block in plastic pocket
183	LD05-S-29	23.08.2005	SS	Sardakhsky Channel site	axe	frozen block in plastic pocket
184	LD05-S-30	23.08.2005	SS	Sardakhsky Channel site	axe	frozen block in plastic pocket
185	LD05-S-31	23.08.2005	SS	Sardakhsky Channel site	axe	frozen block in plastic pocket
186	LD05-S-32	23.08.2005	SS	Sardakhsky Channel site	chain saw	frozen block in plastic pocket
187	LD05-SP-1	23.08.2005	SP	Sardakhsky Channel site	chain saw	bottle
188	LD05-SW-3	23.08.2005	SW	Sardakhsky Channel site	hand	bottle
189	LD05-SW-4	23.08.2005	SW	Sardakhsky Channel	hand	bottle
190	LD05-14C-14	23.08.2005	peat	Sardakhsky Channel site	hand	plastic pocket
191	LD05-RW-1	23.08.2005	RW	Sardakhsky Channel site	hand	bottle
192	LD05-IW-10.1	25.08.2005	IW	Sasyl Ary site	chain saw	big frozen block in plastic pocket
193	LD05-IW-10.2	25.08.2005	IW	Sasyl Ary site	chain saw	big frozen block in plastic pocket
194	LD05-IW-10.3	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
195	LD05-IW-10.4	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
196	LD05-IW-10.5	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
197	LD05-IW-10.6	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
198	LD05-IW-10.7	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
199	LD05-IW-10.8	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
200	LD05-IW-10.9	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
201	LD05-IW-10.10	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
202	LD05-IW-10.11	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
203	LD05-IW-10.12	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
204	LD05-IW-10.13	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
205	LD05-IW-10.14	25.08.2005	IW	Sasyl Ary site	chain saw	frozen slice in plastic pocket
206	LD05-S-33	25.08.2005	SS	Sasyl Ary site	axe	frozen block in plastic pocket
207	LD05-S-34	25.08.2005	SS	Sasyl Ary site	axe	frozen block in plastic pocket
208	LD05-14C-15	25.08.2005	wood	Sasyl Ary site	hand	plastic pocket
209	LD05-99/04	26.08.2005	RW	Samoylov	hand	bottle
210	LD05-IW-11.1	27.08.2005	IW	Kurungnakh site	chain saw	big frozen block in plastic pocket
211	LD05-IW-11.2	27.08.2005	IW	Kurungnakh site	chain saw	big frozen block in plastic pocket

Appendix 5-1: Continuation

Nr	Sample	date	type	location	sampled by	packaging
212	LD05-IW-11.3	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
213	LD05-IW-11.4	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
214	LD05-IW-11.5	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
215	LD05-IW-11.6	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
216	LD05-IW-11.7	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
217	LD05-IW-11.8	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
218	LD05-IW-11.9	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
219	LD05-IW-11.10	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
220	LD05-IW-11.11	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
221	LD05-IW-11.12	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
222	LD05-IW-11.13	27.08.2005	IW	Kurungnakh site	chain saw	frozen slice in plastic pocket
223	LD05-S-35	27.08.2005	SS	Kurungnakh site	axe	frozen block in plastic pocket
224	LD05-S-36	27.08.2005	SS	Kurungnakh site	axe	frozen block in plastic pocket
225	LD05-S-37	27.08.2005	SS	Kurungnakh site	axe	frozen block in plastic pocket
226	LD05-S-38	27.08.2005	SS	Kurungnakh site	axe	frozen block in plastic pocket
227	LD05-14C-16	27.08.2005	peat	Kurungnakh site	axe	frozen block in plastic pocket
228	LD05-99/05	28.08.2005	RW	Samoylov	hand	bottle
229	LD05-SW-5	28.08.2005	SW	Banja Lake, Samoylov	hand	bottle
230	LD05-SW-6	28.08.2005	SW	Lena, Samoylov	hand	bottle
231	LD05-99/06	29.08.2005	RW	Samoylov	hand	bottle
232	LD05-99/07	30.08.2005	RW	Samoylov	hand	bottle
233	LD05-IW-12.1	31.08.2005	IW	Arga Bylyr Areyta	chain saw	big frozen block in plastic pocket
234	LD05-IW-12.2	31.08.2005	IW	Arga Bylyr Areyta	chain saw	big frozen block in plastic pocket
235	LD05-IW-12.3	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
236	LD05-IW-12.4	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
237	LD05-IW-12.5	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
238	LD05-IW-12.6	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
239	LD05-IW-12.7	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
240	LD05-IW-12.8	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
241	LD05-IW-12.9	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
242	LD05-IW-12.10	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
243	LD05-IW-12.11	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
244	LD05-IW-12.12	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
245	LD05-IW-12.13	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
246	LD05-IW-12.14	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
247	LD05-IW-12.15	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
248	LD05-IW-12.16	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
249	LD05-IW-12.17	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
250	LD05-IW-12.18	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
251	LD05-IW-12.19	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
252	LD05-IW-12.20	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
253	LD05-IW-12.21	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
254	LD05-IW-12.22	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket

Appendix 5-1: Continuation

Nr	Sample	date	type	location	sampled by	packaging
255	LD05-IW-12.23	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
256	LD05-IW-12.24	31.08.2005	IW	Arga Bylyr Areyta	chain saw	frozen slice in plastic pocket
257	LD05-IW-12.25	31.08.2005	RIW	Arga Bylyr Areyta	chain saw	frozen block in plastic pocket
258	LD05-IW-12.26	31.08.2005	RIW	Arga Bylyr Areyta	chain saw	frozen block in plastic pocket
259	LD05-IW-12.27	31.08.2005	RIW	Arga Bylyr Areyta	chain saw	frozen block in plastic pocket
260	LD05-IW-12.28	31.08.2005	RIW	Arga Bylyr Areyta	chain saw	frozen block in plastic pocket
261	LD05-MI-6	31.08.2005	MI	Arga Bylyr Areyta	chain saw	frozen block in plastic pocket
262	LD05-MI-7	31.08.2005	MI	Arga Bylyr Areyta	chain saw	frozen block in plastic pocket
263	LD05-MI-8	31.08.2005	MI	Arga Bylyr Areyta	chain saw	bottle
264	LD05-MI-9	31.08.2005	MI	Arga Bylyr Areyta	chain saw	bottle
265	LD05-MI-10	31.08.2005	MI	Arga Bylyr Areyta	chain saw	bottle
266	LD05-MI-11	31.08.2005	MI	Arga Bylyr Areyta	chain saw	bottle
267	LD05-MI-12	31.08.2005	MI	Arga Bylyr Areyta	chain saw	bottle
268	LD05-S-39	31.08.2005	SS	Arga Bylyr Areyta	axe	frozen block in plastic pocket
269	LD05-S-40	31.08.2005	SS	Arga Bylyr Areyta	chain saw	frozen block in plastic pocket
270	LD05-S-41	31.08.2005	SS	Arga Bylyr Areyta	chain saw	frozen block in plastic pocket
271	LD05-S-42	31.08.2005	SS	Arga Bylyr Areyta	chain saw	frozen block in plastic pocket
272	LD05-14C-17	31.08.2005	wood	Arga Bylyr Areyta	hand	frozen block in plastic pocket
273	LD05-14C-18	31.08.2005	peat	Arga Bylyr Areyta	hand	frozen block in plastic pocket
274	LD05-IW-13.1	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	big frozen block in plastic pocket
275	LD05-IW-13.2	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
276	LD05-IW-13.3	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
277	LD05-IW-13.4	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
278	LD05-IW-13.5	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
279	LD05-IW-13.6	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
280	LD05-IW-13.7	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
281	LD05-IW-13.8	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
282	LD05-IW-13.9	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
283	LD05-IW-13.10	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
284	LD05-IW-13.11	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
285	LD05-IW-13.12	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
286	LD05-IW-13.13	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
287	LD05-IW-13.14	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
288	LD05-IW-13.15	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket

Appendix 5-1: Continuation

Nr	Sample	date	type	location	sampled by	packaging
289	LD05-IW-13.16	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
290	LD05-IW-13.17	01.09.2005	IW	Tumatskaya Channel - Site 2	chain saw	frozen slice in plastic pocket
291	LD05-S-43	01.09.2005	SS	Tumatskaya Channel - Site 2	axe	frozen block in plastic pocket
292	LD05-S-44	01.09.2005	SS	Tumatskaya Channel - Site 2	axe	frozen block in plastic pocket
293	LD05-S-45	01.09.2005	SS	Tumatskaya Channel - Site 2	axe	frozen block in plastic pocket
294	LD05-SW-7	01.09.2005	SW	Samoylov	hand	bottle
295	LD05-RIW-1	02.09.2005	RIW	Samoylov	axe	frozen block in plastic pocket
296	LD05-d13C-1	02.09.2005	plant	Samoylov	hand	pocket
297	LD05-d13C-2	02.09.2005	plant	Samoylov	hand	pocket
298	LD05-d13C-3	02.09.2005	plant	Samoylov	hand	pocket
299	LD05-d13C-4	02.09.2005	plant	Samoylov	hand	pocket
300	LD05-d13C-5	02.09.2005	plant	Samoylov	hand	pocket
301	LD05-d13C-6	02.09.2005	plant	Samoylov	hand	pocket
302	LD05-d13C-7	02.09.2005	plant	Samoylov	hand	pocket
303	LD05-d13C-8	02.09.2005	plant	Samoylov	hand	pocket
304	LD05-d13C-9	02.09.2005	plant	Samoylov	hand	pocket
305	LD05-d13C-10	02.09.2005	plant	Samoylov	hand	pocket

Appendix 5-2: List of sediment samples and ice content measurement

Sample	Site	box no	inweight box [g]	box + sample (wet) [g]	box + sample (dry) [g]	Ice content [g]	Ice content (%) to dry weight	remarks
D05-S-1	Samoylov - site 1	-	-	-	-			
LD05-S-2	Samoylov - site 1	397	22,2	54,9	29,9	25	**325**	
LD05-S-3	Samoylov - site 1	20	43,6	125,8	64,1	61,7	**301**	
LD05-S-4	Samoylov - site 2	354	22,3	69,6	51,7	17,9	**61**	
LD05-S-5	Samoylov - site 2	B5	43,9	163,9	100,7	63,2	**111**	
LD05-S-6	Samoylov - site 2	1	43,6	193,8	128,6	65,2	**77**	
LD05-S-7	Samoylov - site 2	14	44,1	156	88,1	67,9	**154**	
LD05-S-8	Samoylov - site 2	22	44,9	160,6	88,2	72,4	**167**	
LD05-S-9	Olenyekskaya Channel - site 1	185	21,5	58,8	39	19,8	**113**	
LD05-S-10	Olenyekskaya Channel - site 1	77	18,1	51,4	20,8	30,6	**1133**	
LD05-S-11	Olenyekskaya Channel - site 1	354	22,3	55,9	27,8	28,1	**511**	
LD05-S-12	Olenyekskaya Channel - site 1	397	22,2	59,5	37,9	21,6	**138**	duplicate
LD05-S-12	Olenyekskaya Channel - site 1	397	22,2	63,7	39,1	24,6	**146**	duplicate
LD05-S-13	Olenyekskaya Channel - site 1	20	43,6	147	100	47	**83**	
LD05-S-14	Olenyekskaya Channel - site 1	1	43,6	145,8	96,8	49	**92**	
LD05-S-15	Tumatskaya Channel site	77	18,1	53,2	33,5	19,7	**128**	
LD05-S-16	Tumatskaya Channel site	354	22,3	59,2	43,8	15,4	**72**	
LD05-S-17	Tumatskaya Channel site	22	44,9	118,3	76,1	42,2	**135**	
LD05-S-18	Tumatskaya Channel site	22	44,9	129,9	88,9	41	**93**	
LD05-S-19	Tumatskaya Channel site	B5	43,9	111,8	82,3	29,5	**77**	
LD05-S-20	Tumatskaya Channel site	22	44,9	178,3	106,6	71,7	**116**	
LD05-S-21	Tumatskaya Channel site	1	43,6	124,3	101,9	22,4	**38**	
LD05-S-22	Tumatskaya Channel site	14	44,1	113,5	86,6	26,9	**63**	
LD05-S-23	Tumatskaya Channel site	77	18,1	56,3	41,7	14,6	**62**	
LD05-S-24	Tumatskaya Channel site	20	43,6	130,1	98,4	31,7	**58**	

Appendix 5-2: Continuation

Sample	Site	box no	inweight box [g]	box + sample (wet) [g]	box + sample (dry)]g]	Ice content [g]	Ice content (%) to dry weight	remarks
LD05-S-25	Tumatskaya Channel site	185	21,5	67,2	49,8	17,4	**61**	
LD05-S-26	Olenyekskaya Channel – site 2	397	22,2	51,9	30	21,9	**281**	
LD05-S-27	Olenyekskaya Channel - site 2	1	43,6	117	64	53	**260**	
LD05-S-28	Sardakhsky Channel site	354	22,3	82,8	65,1	17,7	**41**	
LD05-S-29	Sardakhsky Channel site	185	21,5	51,9	37,2	14,7	**94**	
LD05-S-30	Sardakhsky Channel site	20	43,6	98,1	71,6	26,5	**95**	
LD05-S-31	Sardakhsky Channel site	B5	43,9	94,9	70	24,9	**95**	
LD05-S-32	Sardakhsky Channel site	14	44,1	118,6	74,9	43,7	**142**	
LD05-S-33	Sasyl Ary site	B5	43,9	121,4	77,5	43,9	**131**	
LD05-S-34	Sasyl Ary site	20	43,6	160	137,8	22,2	**24**	
LD05-S-35	Kurungnakh site	354	22,3	46,8	32,1	14,7	**150**	
LD05-S-36	Kurungnakh site	185	21,5	52,9	37	15,9	**103**	
LD05-S-37	Kurungnakh site	77	18,1	56	38,1	17,9	**90**	
LD05-S-38	Kurungnakh site	20	43,6	121,9	79,2	42,7	**120**	
LD05-S-39	Arga Bylyr Areyta	397	22,2	43,8	31,7	12,1	**127**	
LD05-S-40	Arga Bylyr Areyta	14	44,1	112,4	56,6	55,8	**446**	
LD05-S-41	Arga Bylyr Areyta	22	44,9	97,5	53,4	44,1	**519**	
LD05-S-42	Arga Bylyr Areyta	B5	43,9	92,6	59	33,6	**223**	
LD05-S-43	Tumatskaya Channel - Site 2	354	22,3	65,9	41,5	24,4	**127**	
LD05-S-44	Tumatskaya Channel - Site 2	185	21,5	54,3	44,7	9,6	**41**	
LD05-S-45	Tumatskaya Channel - Site 2	20	43,6	135,2	93,6	41,6	**83**	

Appendix 5-3: List of water samples

Nr	Sample	date	type	location	pH	Conductivity	Isotopes	Hydrochemistry	sampled by	packaging
1	LD05-99/01	12.08.2005	RW	Samoylov - house	5,78	25	X	X	hand	bottle
2	LD05-IW-1.30	14.08.2005	RIW	Samoylov - site 1	6,37	50,8	X	X	chain saw	bottle
3	LD05-IW-4.1	15.08.2005	IW	Samoylov - site 2	6,76	65,3	X	X	axe	bottle
4	LD05-IW-4.2	15.08.2005	IW	Samoylov - site 2	-	-	X	-	axe	bottle
5	LD05-IW-4.3	15.08.2005	IW	Samoylov - site 2	7,69	68,6	X	X	axe	bottle
6	LD05-IW-4.4	15.08.2005	IW	Samoylov - site 2	-	-	X	-	axe	bottle
7	LD05-IW-4.5	15.08.2005	IW	Samoylov - site 2	7,76	98,3	X	X	axe	bottle
8	LD05-TI-1	15.08.2005	TI	Samoylov - site 2	7,29	76,2	X	X	chain saw	bottle (=S7)
9	LD05-RI-1	15.08.2005	RI	Samoylov - site 2	7,21	28,7	X	X	axe	bottle
10	LD05-RI-2	15.08.2005	RI	Samoylov - site 2	-	-	X	-	axe	bottle
11	LD05-99/02	16.08.2005	RW	Samoylov - house	-	-	X	-	hand	bottle
12	LD05-MI-1	17.08.2005	MI	Olenyekskaya Channel - site 1	7,33	72,2	X	X	chain saw	bottle
13	LD05-MI-2	17.08.2005	MI	Olenyekskaya Channel - site 1	-	-	X	-	chain saw	bottle
14	LD05-MI-3	17.08.2005	MI	Olenyekskaya Channel - site 1	6,61	16,8	X	X	chain saw	bottle
15	LD05-MI-4	17.08.2005	MI	Olenyekskaya Channel - site 1	6,62	7,5	X	-	axe	bottle
16	LD05-MI-5	17.08.2005	MI	Olenyekskaya Channel - site 1	6,36	21,8	X	X	axe	bottle
17	LD05-SW-1	17.08.2005	SW	Olenyekskaya Channel	7,12	111,9	X	X	hand	bottle
18	LD05-SW-2	19.08.2005	SW	Tumatskaya Channel	7,3	124,1	X	X	hand	bottle
19	LD05-99/03	21.08.2005	RW	Samoylov	6,25	21,4	X	X	hand	bottle
20	LD05-SP-1	23.08.2005	SP	Sardakhsky Channel site	5,92	4,2	X	X	chain saw	bottle
21	LD05-SW-3	23.08.2005	SW	Sardakhsky Channel site	-	-	X	-	hand	bottle
22	LD05-SW-4	23.08.2005	SW	Sardakhsky Channel	7,04	113,5	X	X	hand	bottle
23	LD05-RW-1	23.08.2005	RW	Sardakhsky Channel site	-	-	X	-	hand	bottle
24	LD05-99/04	26.08.2005	RW	Samoylov	6,55	68	X	X	hand	bottle
25	LD05-99/05	28.08.2005	RW	Samoylov	6,54	64,8	X	X	hand	bottle
26	LD05-SW-5	28.08.2005	SW	Banja Lake, Samoylov	7,19	93,6	X	X	hand	bottle
27	LD05-SW-6	28.08.2005	SW	Lena, Samoylov	7,19	142,2	X	X	hand	bottle
28	LD05-99/06	29.08.2005	RW	Samoylov	6,9	12,3	X	X	hand	bottle
29	LD05-99/07	30.08.2005	RW	Samoylov	6,39	15,1	X	X	hand	bottle
30	LD05-MI-8	31.08.2005	MI	Arga Bylyr Areyta	-	-	X	-	chain saw	bottle
31	LD05-MI-9	31.08.2005	MI	Arga Bylyr Areyta	-	10,4	X	X	chain saw	bottle
32	LD05-MI-10	31.08.2005	MI	Arga Bylyr Areyta	7,83	167,5	X	X	chain saw	bottle
33	LD05-MI-11	31.08.2005	MI	Arga Bylyr Areyta	-	-	X	-	chain saw	bottle
34	LD05-MI-12	31.08.2005	MI	Arga Bylyr Areyta	7,13	6,1	X	X	chain saw	bottle
35	LD05-SW-7	01.09.2005	SW	Samoylov	7,6	143,5	X	X	hand	bottle

6. Report on hydrological work in the Lena River Delta in August 2005

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6.1 Introduction

Hydrological measurements were carried out during the expedition to the Lena Delta in the summer of 2005. They were a continuation of previous investigations of the hydrological, hydrodynamic, and bed-deformation processes in the main Channels and representative points of the Lena River Delta.

This study was part of the “Laptev Sea System” project and supported by a grant of Russian Foundation for Basic Research: No. 05-05-64419-02 “Hydromorphogenesis of the Lena River Delta”.

Measurements were made using a ship (the Neptun) of the hydrological station and a small motorboat.

The investigation can be divided into four primary parts:

1. Study at a daily station in the Olenekskaya Channel mouth.
2. Study along the Olenekskaya Channel from its mouth to the Bulkurskaya branch.
3. Study around Sardakh Island: on the Sardakhskaya and Bolshaya Trofimovskaya Channels.
4. Study of the main Channels of the Lena River delta: Bykovskaya, Trofimovskaya, Tumatskaya, Main bed, Olenekskaya.

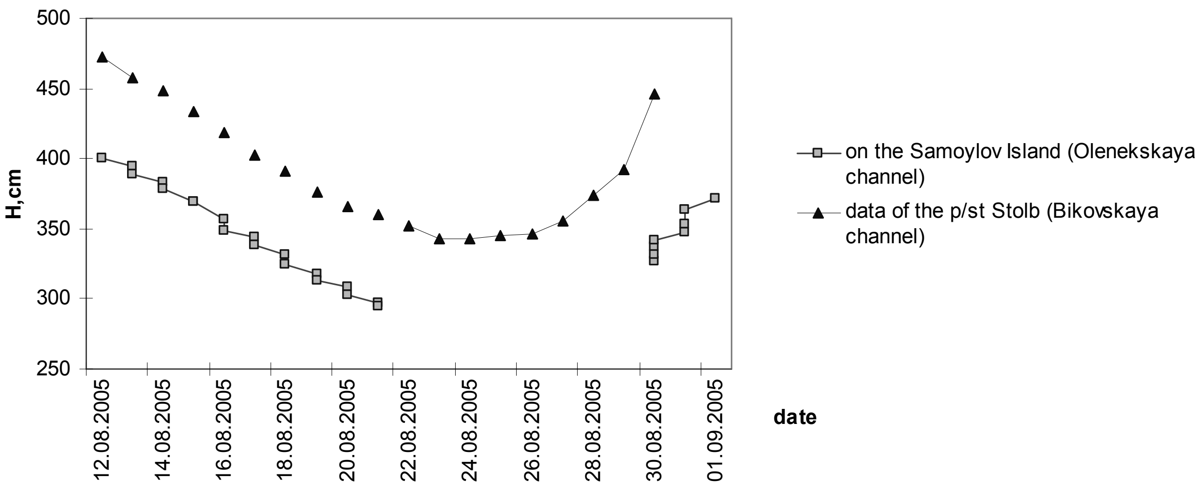

Figure 6-1: Olenekskaya and Bykovskaya Channels’ water level in August 2005

Fifteen discharge gauging profiles were measured during August 2005. Their location is shown in Table 6-1.

Table 6-1: The hydrological gauging profile locations

Profile Number	Sampling Location	Date	Maximal depth [m]	Longitude, N	Latitude, E
Profile 1	Olenekskaya Ch., daily station	15.08.05, 16.08.05, 17.08.05	22,7	72°52'48,3"	127°12'53,6"
Profile 2	Angardam Ch.	18.08.05	16,5	72°45'25,4"	123°38'54,1"
Profile 3	Olenekskaya Ch.	19.08.05	6,6	72°39'25,2"	124°20'20,8"
Profile 4	Olenekskaya Ch.	19.08.05	8,3	72°30'20,9"	125°17'10,4"
Profile 5	Olenekskaya Ch.	20.08.05	17,8	72°21'32,4"	125°40'16,2"
Profile 6	Olenekskaya Ch., hydrometrical gauge line	20.08.05	9,2	72°17'46,1"	126°05'40,0"
Profile 7	Bulkurskaya Ch.	20.08.05	7,3	72°13'57,7"	126°06'18,5"
Profile 8	Sardahskaya Ch.	23.08.05	27,8	72°34'50,0"	127°11'55,4"
Profile 9	Trofimovskaya Ch.	23.08.05	22	72°36'52,5"	127°15'30,0"
Profile 10	Bykovskaya Ch., hydrometrical gauge line	24.08.05	12,5	72°24'28,0"	126°54'47,9"
Profile 11	Main Ch. of the Lena River, hydrometrical gauge line	25.08.05	34,9		
Profile 12	Trofimovskaya Ch., hydrometrical gauge line	25.08.05	13,3		
Profile 13	Tumatskaya Ch., hydrometrical gauge line	27.08.05	12,6	72°25'06,4"	126°27'23,6"
Profile 14	Sardahskaya Ch.	24.08.05	24,1	72°38'18,8"	127°51'41,2"
Profile 15	Sardahskaya Ch.	25.08.05	19,8	72°30'53,7"	128°29'11,5"

The following measurements were conducted:

- Levelling of a temporary sectional staff gauge on the Olenekskaya Channel.
- Water level measurements on the Olenekskaya Channel gauges (one of them located in the channel mouth, and the second on Samoylov Island, Figure 6-1).
- Water discharge and suspended sediment supply observations at the daily station during different stages of surge.
- Water discharge and suspended sediment supply observations at the main and secondary channels of the Lena delta.
- Coring of lacustrine surface sediment from three lakes of the delta's 1st terrace (Table 6-2).
- Water, solid and suspended particulate materials (SPM) sampling for hydrochemical, geochemical, total and organic carbon content (TOC/TC), and grain-size. Isotopes were analyzed for samples from the delta's channels, lakes, a stream, and a sea bay.
- Preliminary hydrochemical analysis and runoff calculation in the field.

Table 6-2: Location of the lakes where sediment cores were taken in August 2005 (Ch. = Channel)

№	Lake Name/Number	Date	Core length [cm]	Comments	Location	
					Longitude, N	Latitude, E
1	Lake "Schakhtnoye"	20.08.05	53	1st terrace	72°20'43,1"	125°40'09,5"
2	Lake №1 on Chay-Aryi Island	24.08.05	Surface	1st terrace	Chay-Aryi Island	
3	Lake №2 on Chay-Aryi Island	31.08.05	17	1st terrace	Chay-Aryi Island	

6.2 Methods

All gauge lines were located in representative channel stretches. Location was measured using GPS. Depth measurements were made with an echo-sounding device (Garmin) from a motorboat and made at one-meter intervals in both channel branches. At characteristic bed relief points some measuring verticals were fixed. There were usually 4 to 7 verticals per profile. Observations were made for five horizons at each vertical: surface; 0,2H; 0,6H; 0,8H, and bottom (where H is the water depth at the vertical). There were four main values for observations: water velocity, water sampling, temperature, and depth measurement. Water velocity values were used for water discharge calculation. Water velocity was measured using a hydrological water speed indicator (GR-21). Water was sampled for hydrochemical analyses and filtered for turbidity measurement (and suspended sediment supply), geochemical and TOC/TC analyses. Water was sampled using a vacuum bathometer at a specific water depth (Table 6-3). And filtered through 10 cm diameter paper filters on a Kuprina device. Then turbidity and water discharge were combined to calculate suspended materials supply. For geochemical analysis of suspended particulate matter (SPM) and for TOC/TC, polycarbonate (PC)and cellulose acetate filters (GF), respectively, with diameters of 4.5 cm were used. Sampling locations are listed in Table 6-4. All filters were dried and weighed at the Otto Schmidt Laboratory in the Arctic and Antarctic Research Institute (AARI), where some of the analyses are planned. Most of the analyses will occur at the AWI (Potsdam) laboratory.

Water temperature and water depth were measured using an echo-sounding device.

Past geochemical conditions of the investigated area are studied by means of lacustrine surface sediment core analyses. Cores were taken using the GOIN tube corer. A core taken from Lake Shakhtnoye core was separated into 16 layers differing in their sediment structure (Table 6-5). Cores from two lakes of the 1st terrace on Chay-Ary Island will also be analyzed. One of the cores contained surface sediments (lake 1); the other was divided into 6 sediment layers. The possibility of precipitation and accumulation of different types of material in bottom sediments will be investigated using the collected bed samples (Table 6-5).

Table 6-3: List of water samples and planned analyses (Ch. = Channel)

Sample No	Sample location	Date	Depth, [m]	Longitude, N	Latitude, E	Eh, [µS/cм]	Hydrochemistry	Isotope analyses
1.1	Olenekskaya Ch., Profile 1	15.08.05	17,76	72°52'48,3"	127°12'53,6"	115,4	+	+
1.2	Olenekskaya Ch., Profile 1	15.08.05	4,44	72°52'48,3"	127°12'53,6"	105,6	+	+
1.3	Olenekskaya Ch., Profile 1	16.08.05	19,96	72°52'48,3"	127°12'53,6"	103,6	+	+
1.4	Olenekskaya Ch., Profile 1	16.08.05	4,24	72°52'48,3"	127°12'53,6"	125,3	+	+
1.5	Olenekskaya Ch., Profile 1	17.08.05	17,44	72°52'48,3"	127°12'53,6"	110	+	+
1.6	Olenekskaya Ch., Profile 1	17.08.05	4,36	72°52'48,3"	127°12'53,6"	109,1	+	+
1.7	Kuba Bay	17.08.05	surface			24,5 mS/cm	+	+
1.8	Lagoon lake nearby the Kuba Bay	17.08.05	surface			2,24 mS/cm	+	+
1.9	Angardam Ch., Profile 2	18.08.05	12	72°45'25,4"	123°38'54,1"	107	+	+
1.10	Angardam Ch., Profile 2	18.08.05	9	72°45'25,4"	123°38'54,1"	117	+	+
1.11	Angardam Ch., Profile 2	18.08.05	3	72°45'25,4"	123°38'54,1"	108	+	+
1.12	Tas-yuryage River	18.08.05	surface			88	+	+
1.13	Olenekskaya Ch., Profile 3	19.08.05	5,12	72°39'25,2"	124°20'20,8"	108,9	+	+
1.14	Olenekskaya Ch., Profile 3	19.08.05	1,28	72°39'25,2"	124°20'20,8"	108,7	+	+
1.15	Lake 1 on the 1st terrace	19.08.05	surface	72°35'08,3"	124°56'28,7"	104,1	+	+
1.16	Olenekskaya Ch., Profile 4	19.08.05	6,48	72°30'20,9"	125°17'10,4"	113	+	+
1.17	Olenekskaya Ch., Profile 4	19.08.05	1,62	72°30'20,9"	125°17'10,4"	115,1	+	+
1.18	Olenekskaya Ch., Profile 5	20.08.05	14,24	72°21'32,4"	125°40'16,2"	118,5	+	+
1.19	Olenekskaya Ch., Profile 5	20.08.05	3,56	72°21'32,4"	125°40'16,2"	117,5	+	+
1.20	Lake "Shakhtnoye" on the 1st terrace	20.08.05	surface	72°20'43,1"	125°40'09,5"	81,7	+	+
1.21	Olenekskaya Ch., Profile 6	20.08.05	1,82	72°17'46,1"	126°05'40,0"	139,7	+	+
1.22	Olenekskaya Ch., Profile 6	20.08.05	7,24	72°17'46,1"	126°05'40,0"	139,4	+	+
1.23	Bulkurskaya Ch., Profile 7	20.08.05	4,32	72°13'57,7"	126°06'18,5"	103	+	+
1.24	Sardahskaya Ch., Profile 8	23.08.05	surface	72°34'50,0"	127°11'55,4"	105,2	+	+
1.25	Sardahskaya Ch., Profile 14	24.08.05	6,36	72°38'18,8"	127°51'41,2"	109,3	+	+
1.26	Sardahskaya Ch., Profile 15	25.08.05	14,88	72°30'53,7"	128°29'11,5"	111,4	+	+
1.27	Trofimovskaya Ch., Profile 9	23.08.05	surface	72°36'52,5"	127°15'30,0"	107,7	+	+
1.28	Bikovskaya Ch., Profile 10	24.08.05	2,40	72°24'28,0"	126°54'47,9"	110,5	+	+
1.29	Bykovskaya Ch., Profile 10	24.08.05	9,60	72°24'28,0"	126°54'47,9"	110	+	+
1.30	Main Channel of the Lena River, Profile 11	25.08.05	18,90			118,7	+	+
1.31	Trofimovskaya Ch., Profile 12	25.08.05	2,56			129,9	+	+
1.32	Tumatskaya Ch., Profile 13	27.08.05	2,54	72°25'06,4"	126°27'23,6"	135,7	+	+
1.33	Lake 2 on the Chay-Ari Island	31.08.05	surface			111	+	+
1.34	Ice from Olenekskaya Ch.	17.08.05	inside	72°52'48,3"	127°12'53,6"			+

Table 6-4. List of SPM samples, the Lena Delta, 2005

№	Number of **PC** filters	Number of **GF** filters	Sampling Location	TOC	TC	Geochemistry
1		GF 1	Profile 15	+	+	
2		GF 2	Profile 14	+	+	
3		GF 13	Profile 11	+	+	
4		GF 15	Profile 3	+	+	
5		GF 16	Profile 6	+	+	
6		GF 17	Profile 2	+	+	
7		GF 18	Profile 3	+	+	
8		GF 19	Profile 4	+	+	
9		GF 20	Profile 10	+	+	
10		GF 49	Profile 1, 17.08.05	+	+	
11		GF 50	Profile 13	+	+	
12		GF 51	Profile 8	+	+	
13		GF 52	Profile 1, 16.08.05	+	+	
14		GF 53	Profile 13	+	+	
15		GF 54	Profile 10	+	+	
16		GF 55	Profile 5	+	+	
17		GF 56	Profile 9	+	+	
18		GF 57	Profile 7	+	+	
19		GF 58	Profile 12	+	+	
20		GF 59	Profile 1, 15.08.05	+	+	
21		GF 60	Profile 6	+	+	
22		GF 86	Profile 12	+	+	
23	PC 1		Profile 14			+
24	PC 2		Profile 6			+
25	PC 161		Profile 12			+
26	PC 162		Profile 8			+
27	PC 163		Profile 5			+
28	PC 164		Profile 1, 15.08.05			+
29	PC 170		Profile 2			+
30	PC 171		Profile 4			+
31	PC 172		Profile 5			+
32	PC 173		Profile 3			+
33	PC 174		Profile 4			+
34	PC 177		Profile 7			+
35	PC 178		Profile 1, 16.08.05			+
36	PC 179		Profile 11			+
37	PC 180		Profile 13			+
38	PC 206		Profile 15			+
39	PC 213		Profile 1, 16.08.05			+
40	PC 214		Profile 1, 17.08.05			+
41	PC 215		Profile 1, 15.08.05			+
42	PC 216		Profile 9			+
43	PC 218		Profile 10			+

Table 6-5. List of lacustrine sediment cores and bed-samples from the Lena River Delta Channels 2005 and analyses that are planed to be observed

№	Lake	Layer of the cores	TOC	TC	Geo-chemistry	Grain-size
1	Lake "Shakhtnoye" on the 1st terrace N 72°20'43,1"; E 125°40'09,5" 20.08.05	0-2	+	+	+	+
2		2-5	+	+	+	+
3		5-8	+	+	+	+
4		8-12	+	+	+	+
5		12-15	+	+	+	+
6		15-20	+	+	+	+
7		20-25	+	+	+	+
8		25-27	+	+	+	+
9		27-30	+	+	+	+
10		30-33	+	+	+	+
11		33-36	+	+	+	+
12		36-38	+	+	+	+
13		38-42	+	+	+	+
14		42-45	+	+	+	+
15		45-49	+	+	+	+
16		49-53	+	+	+	+
17	Lake № 1 on Chay-Ary Island on the 1st terrace 24.08.05 Surface of sediments	top	+	+	+	+
18		bottom	+	+	+	+
19	Lake № 2 on Chay-Ary Island on the 1st terrace 31.08.05	0-2	+	+	+	+
20		2-4	+	+	+	+
21		4-7	+	+	+	+
22		7-10	+	+	+	+
23		10-14	+	+	+	+
24		14-17	+	+	+	+
25	Tumatskaya Ch. left bank	bottom	+	+	+ ?	+
26	Main Ch. Ch.	bottom	+	+	+ ?	+
27	Olenekskaya Ch.	bottom	+	+	+ ?	+
28	Trofimovskaya Ch.	bottom	+	+	+ ?	+
29	Tumatskaya Ch. right bank	bottom	+	+	+ ?	+
30	Bulkurskaya Ch.	bottom	+	+	+ ?	+
31	Trofimovskaya Ch.	bottom	+	+	+ ?	+
32	Angardam Ch.	bottom	+	+	+ ?	+

6.3 Preliminary results

Water discharge and suspended material supply measured at the gauging profiles are shown in Fig. 6-2 and 6-3 and in Table 6. The main channelscontribute decreasing amounts of discharge in the order: Trofimovskaya Channel, Bykovskaya, Olenekskaya, and the minor one is Tumatskaya. After Sardakh Island, water is mainly transported into the Sardahskaya Channel. Discharge decreases towards the channel mouth (the gauging station near Sobo-Sise Island) due to the hydraulic head of seawater. The same situation was noticed for the Olenekskaya Channel estuary. Tumatskaya Channel has contributed very little discharge for the three-year period of observation in the delta. Extinction of this branch could therefore be a possibility.

Investigations of the Angardam Channel have shown an increase of erosion in this branch. Complementary measurements in this area are required to clarify the responsible processes and rate of change.

Twice-daily investigations in the Olenekskaya Channel revealed an abnormal correlation between minimum water velocity and maximum turbidity. We suggest that seawater influx into the channels is responsible. The observed high turbidity would then correspond to coagulation and flocculation processes.

Comparison of water turbidity and velocity distribution in horizontal and vertical sections of the gauging station do not demonstrate a consistent correlation. If water speed depends on bed morphology, then turbidity reflects the hydraulic character of the river channel.

The visual character of the sediment cores (availability of different layers) suggests rapid changes in environmental conditions in the Lena Delta. Geochemical, granulometrical and other analyses will provide more information.

6.4 Conclusion

In August 2005 hydrological field measurements were carried out to extend previous investigations and included standard hydrometrical measurements, confirmation of previous results, and collecting new information.

Some areas of intensive erosion in the delta had been observed before, and this field campaign added extra information and observation points: these are the Sardakhsko-Trofimovskiy, Bulkursko-Olenekskiy, and Oleneksko-Angardamskiy junctions. Sea level fluctuation and run-off have an increasing influence on water redistribution between channels and on the intensity of erosion processes in riverbeds. Trends in bed transformation in the Lena delta were measured.

Hydrological observations in channel mouths and on the Angardam Branch were done for the first time in the Lena delta.

Lacustrine surface sediment cores as well as geochemical records of the paleo- and current environment of the delta were collected.

In addition, other areas of the delta, such as the Tumatskaya Channel, were chosen for further study. Palaeo-hydrological reconstruction demands special knowledge and subsidiary expedition measurements.

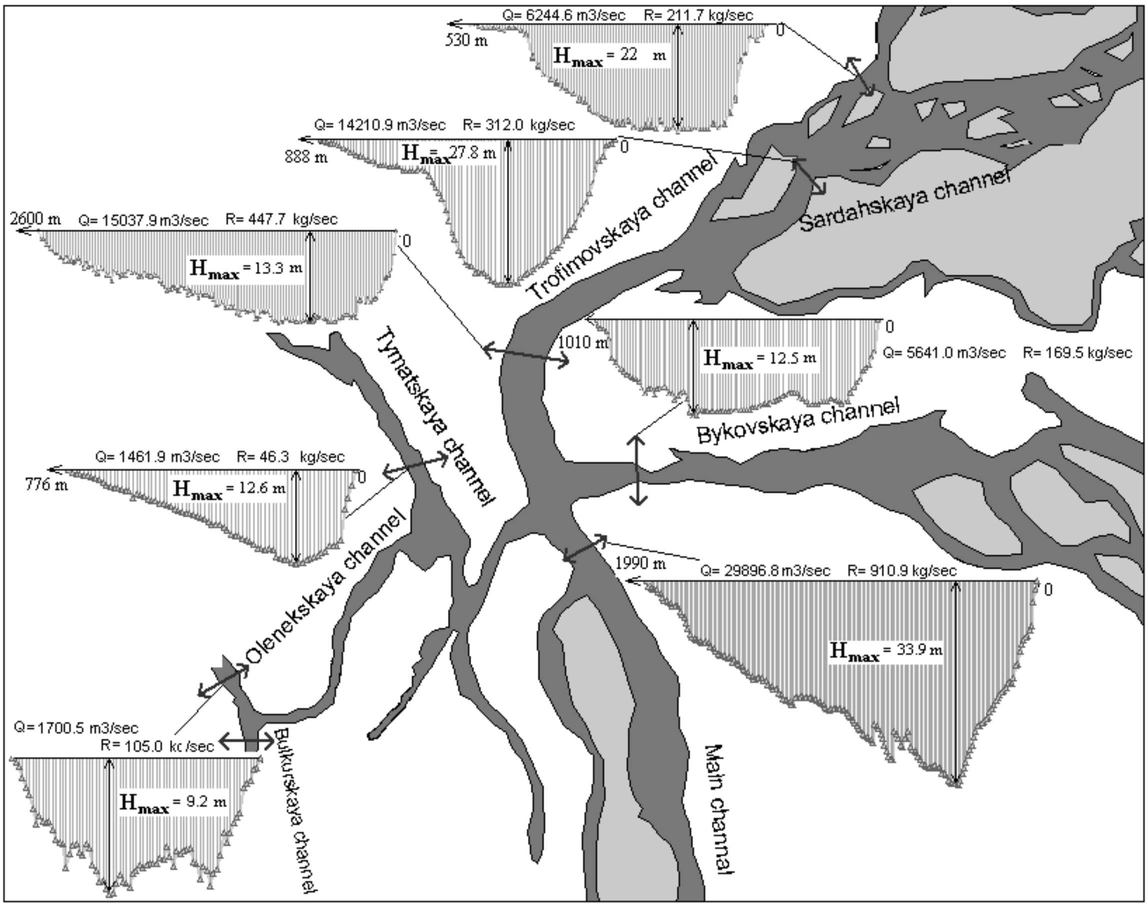

Figure 6-2: Water discharge and suspended supply of main channels of the Lena River Delta

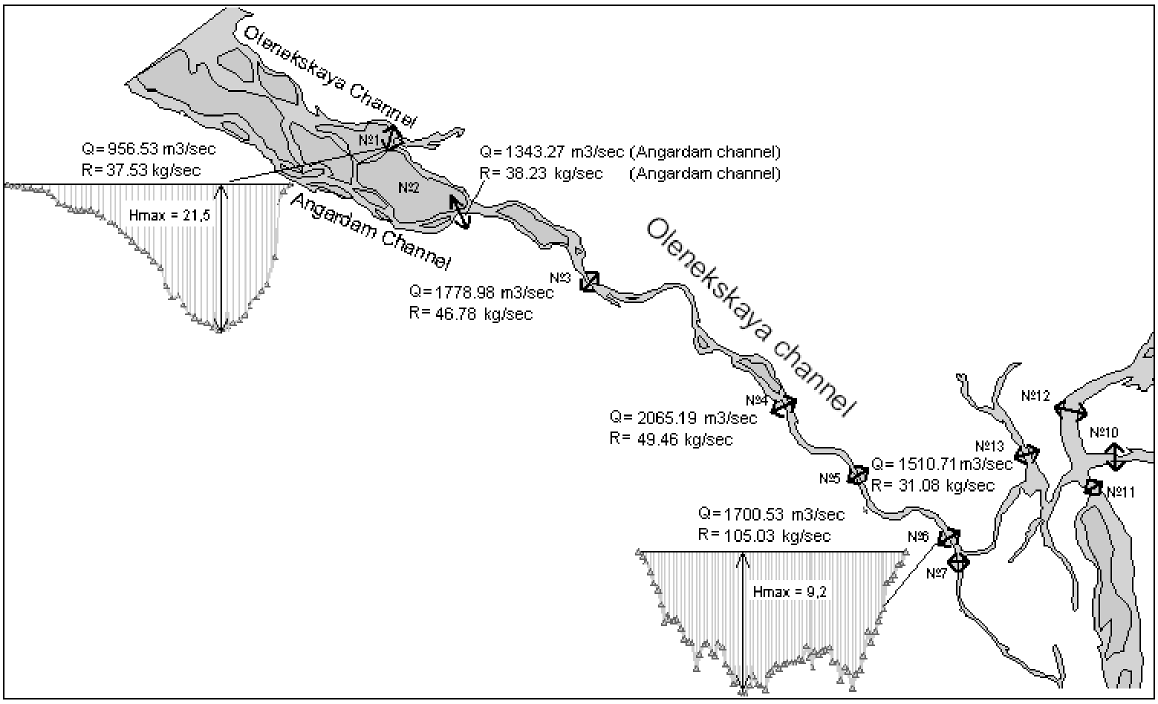

Figure 6-3: Water discharge and suspended supply at the gauging stations of the Olenekskaya and Angardam Channels.

Table 6-6: Measured water discharge and suspended sediment supply of gauging stations on the main channels of the Lena Delta, August 2005

Gauging Station No	Name of Channel	Water discharge Q, m^3/s	Suspended supply R, kg/s	Date	Gauging station location
1	Olenekskaya Ch., daily station	882.3	15.5	15.08.05	Daily station near p. Nagym
		1380.9	22.0	16.08.05	
		922.3	36.2	17.08.05	
2	Angardam Ch.	1336.9	38.1	18.08.05	2 km from the Olenekskaya Ch.
3	Olenekskaya Ch.	1810.3	59.5	19.08.05	
4	Olenekskaya Ch.	2010.0	47.2	19.08.05	Near Gusinka River
5	Olenekskaya Ch.	1511.5	30.4	20.08.05	Near p. Chay-Tumus
6	Olenekskaya Ch., hydrometrical gauge line	1692.7	36.2	20.08.05	Main hydrometrical gauging station
7	Bulkurskaya Ch.	106.3	0.42	20.08.05	2 km before to the Olenekskaya Ch. flowing
8	Sardahskaya Ch.	14210,9	312,1	23.08.05	Near Sardah Island
9	Trofimovskaya Ch.	6244.6	211.7	23.08.05	Near Gogolevskiy Island
10	Bikovskaya Ch., hydrometrical gauge line	5641.0	169.5	24.08.05	Main hydrometrical gauge line
11	Main Ch. of the Lena River, hydrometrical gauge line	29896.9	911.0	25.08.05	Main hydrometrical gauge line, 4.7 km from Stolb Island
12	Trofimovskaya Ch., hydrometrical gauge line	15037.9	447.7	25.08.05	Main hydrometrical gauging station
13	Tumatskaya Ch., hydrometrical gauge line	1461.9	46.3	27.08.05	Main hydrometrical gauging station
14	Sardahskaya Ch.	6811,5	171,7	24.08.05	Near Bur-Kuopput Island
15	Sardahskaya Ch.	4334,3	102,8	25.08.05	Near Sobo-Sise Island, 30 km from a mouth of channel

Russian-German Cooperation Yakutsk– Potsdam:

The Expedition CENTRAL YAKUTIA 2005

by the participants of the expedition

edited by,

Bernhard Diekmann, Sebastian Wetterich, Frank Kienast

Contents

Central Yakutia 2005

1. Expedition 'Verkhoyansk 2005' • Limnogeological studies at Lake Billyakh, Verkhoyansk Mountains, Yakutia

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Figure 1-1: The Field team of expedition 'Verkhoyansk 2005'. From left to right: Andrei Andreev, Dmitry Subetto, Luidmilla Pestryakova, Dmitry Grusznykh, Bernhard Diekmann, Gerald Müller, Hermann Lüpfert.

1.1 Introduction

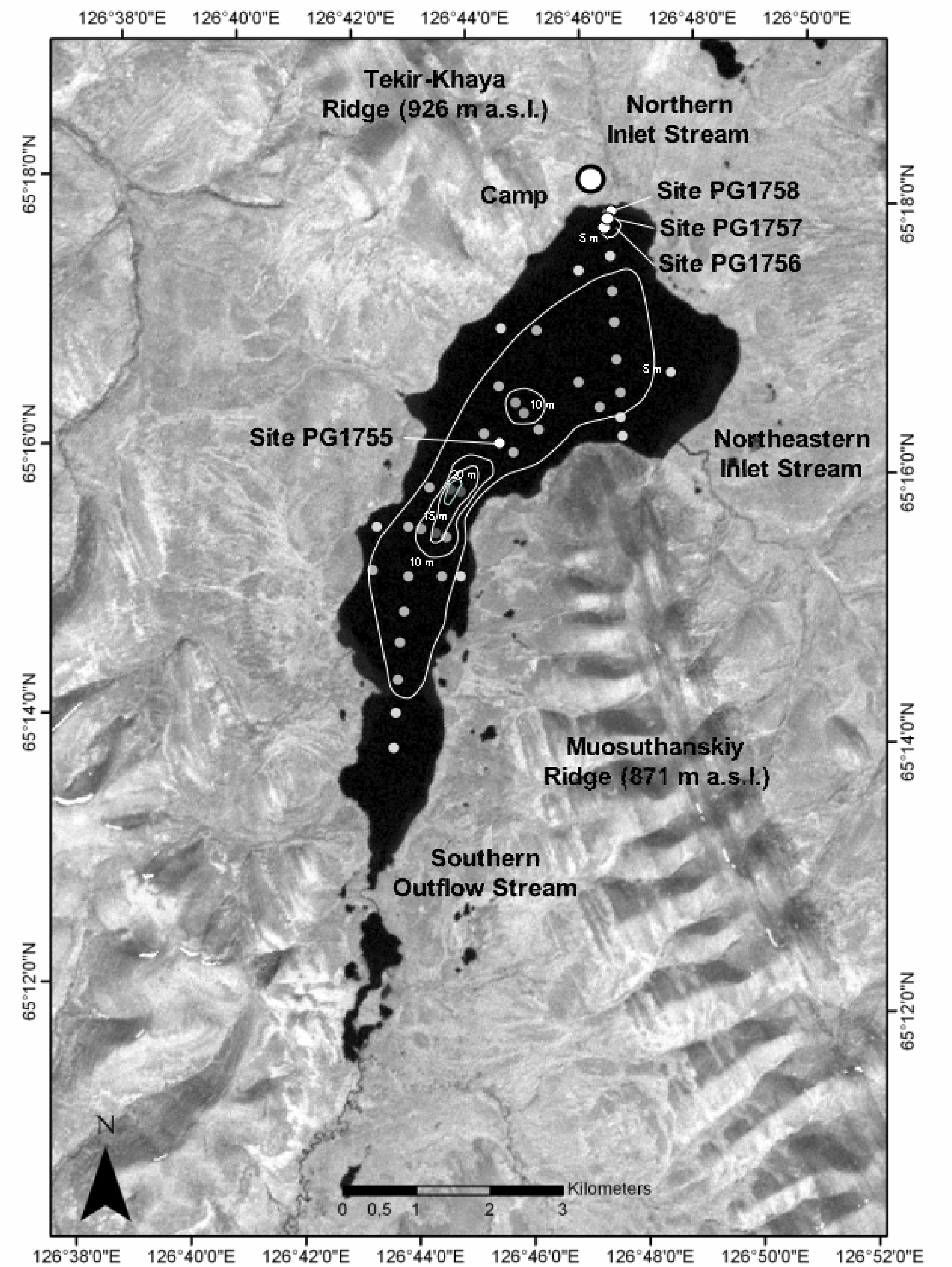
The study of Lake Billyakh was stimulated through foregoing Russian-German expeditions in the central Verkhoyansk Mountains during the summer seasons 2002 and 2003. The former studies dealt with the regional landscape development during the late Quaternary with special emphasis on the chronological development of mountain glaciations, permafrost dynamics, peat formation, and the origin of fluvial and loess-like sediments (Popp et al., 2006, submitted; Stauch et al., in press; Werner, 2006). Palaeolimnological studies, so far, were concentrated on Holocene thermokarst lakes in the Central Yakutian low lands (Diekmann et al., 2005; Wetterich et al., this volume). Holocene lacustrine records were not available until the expedition. The former studies in the Verkhoyansk Mountains have confirmed the presence of repeated glacial advances, as outlined in older Russian literature (Kind, 1975; Zamoruyev, 2004), and resulted in a refined chronstratigraphic interpretation of glacial fluctuations in the past (Stauch, 2006; Stauch et al., in press). It became evident that regional mountain glaciers reached the Verkhoyansk foreland only before 100 ka BP and glaciations younger than 50 ka BP were restricted to the mountain ranges. The Lake Billyakh area, although situated in the mountains, was ice-free since at least 80 ka BP. Therefore, it was expected that Lake Billyakh may provide a continuous lacustrine sediment section spanning the mid- to late Weichselian cold climate stage and the Holocene. The objective of the expedition was the retrieval of long sediment cores for later multi-proxy palaeolimnological analyses in connection with a survey of lake hydrology and bathymetry and georadar measurements of the sedimentary basin infill. The study is designed to contribute to a better understanding of late Quaternary regional palaeoenvironmental changes at high temporal resolution.

Figure 1-2: Location map of Lake Billyakh in Yakutia, northeastern Siberia.

1.2 Regional Setting of Lake Billyakh

Lake Billyakh is situated in the central Verkhoyansk Mountains at 340 m a.s.l. (65.2°N, 120.7°E) (Figure 1-2). The surrounding mountain peaks rise up to 926 m a.s.l. (Figures 1-3, 1-4). The area is under strong permafrost conditions. Northern Larch (*Larix dahurica*) taiga dominates the vegetation. Above approximately 450 m a.s.l., the taiga is replaced by mountain tundra. The climate is affected by severe continental conditions near the cold pole of the northern hemisphere. Winter temperatures may drop down to below 50°C and occasionally reach maxima of about 30°C during summer time. The 11x3 km big lake probably is of tectonic origin and occupies a NE-SW trending basin that perpendicularly cuts through the Muosuthanskiy and Tekir-Khaya Ridges (Figure 1-4). The mountain ranges are built up of northeastward dipping Permian-Triassic sandstones and shales that form the most widespread exposures in the Verkhoyansk fold-and-thrust belt (Figure 1-3). In addition to tectonic faulting, the lake basin was subsequently sculptured by glacier advances, as evidenced by the glacial landforms (kars, moraines, U-valleys) around the lake. Along the southeastern shore, a terrace-like feature, three metres above the present lake-level, points to a higher lake-level stand in the past. Today the lake is fed by small creeks from the surrounding mountain slopes. Two small perennial streams enter the lake at its northern and northeastern end, respectively. The drainage of the lake appears through an outflow at the southernmost narrow end of the lake and is directed towards the Lena (Figure 1-4).

Figure 1-3: Camp at the northern end of Lake Billyakh and southward view across the 11 km long lake. The mountain range to the left is the Muosuthansky Ridge (871 m a.s.l.) that is composed of Permian-Triassic shales and sandstones of the Verkhoyansk fold- and thrust belt. The dipping of strata to the northeast is nicely displayed by the flat-iron structures exposed at the slope of the ridge.



compiled by Georg Stauch, RWTH Aachen). Bathymetric contour lines are inferred from depth soundings through ice drill holes (grey dots). Sediment cores were taken in the central part of the lake and along a depth transect near the northern shore.

1.3 Itinerary

The expedition took place in spring 2005. The AWI field equipment was sent in March to Yakutsk by air freight. With regular flights, the AWI participants arrived on 5th April in Yakutsk. Because of problems with customs clearance, the equipment was unloaded after a long delay on 14th April. The time in Yakustk was used for logistical preparation of field work and field experiments with the georadar system, which already was available, because it was carried as hand baggage to Yakutsk.

The expedition to Lake Billyakh started in the morning of 16th April from the Magan airport near Yakutsk. Transportation of the field equipment and expedition team (see author list and Fig. 1) was achieved by helicopter flight. After a 1.5-hour flight, the Russian field guide, Dmitry Gruznykh, joined the team in Sangar. Lake Billyakh was reached one hour later in the early afternoon. The field camp was settled in a hunting lodge at the northern shore of the lake (Fig. 3). During the following two days, a depth survey of Lake Billyakh was conducted and provided a good data base for the selection of coring sites. After this initial stage of field work, the snow vehicle broke down and drastically restricted the range of operation. Sediment coring therefore was concentrated on the northern part of the lake, which was accessible by walk and (menhorse)-sledge within reasonable time. Coring work started on 19th April and was finished on 26th April. At the first site, the coring string teared apart after 10-m penetration into the stiff and semiconsolidated lake mud. During the recovery of the coring equipment through big ice holes, three rods of the coring equipment were deformed. In spite of all these unusual technical problems, the team stayed in good mood and during the following days was able to retrieve representative sediment records from the lake. The weather conditions mostly were dominated by high-pressure cloudless conditions with temperatures in the range between -20°C and 0°C. Occasional snow precipitation occurred during the warmer and cloudy days. The lake ice cover was 1.5 m thick, covered by 60 cm of snow. During the last days, the seasonal snow melt started and slightly complicated transportation of the equipment on the lake. The helicopter flight back to Yakutsk was postponed five times, because of bad weather conditions in Sangar. On 1st May the field team returned to Yakutsk.

The last days in Yakutsk were used for presentations at Yakutsk University and the organization of the air freight to Potsdam. On 6th May, the AWI group departed back to Germany.

1.4 Methods

1.4.1 Bathymetric measurements

In order to select suitable sites for sediment coring, a depth survey of Lake Billyakh was conducted. Because the lake never has been studied in the past, no depth data were available. The original plan was to carry out depth and sediment profiling by means of georadar measurements with a RAMAC-GPR unit, equiped with both 50 and 10 Mhz antennas. It turned out that the georadar system was not applicable, owing to the thick ice and snow covers on the lakes that produce strong electromagnetic reflections and blur the sedimentary reflectors in the relatively shallow lake. The georadar system already failed in the thermokarst lakes around Yakutsk, which were surveyed during the long stay in Yakutsk prior to the start of the Billyakh campaign. The undertaken bathymetric measurements are based on cable soundings along a network of drill holes across the entire lake. Drill holes through the ice cover were drilled with a Jiffy driller.

1.4.2 Water sampling and measurements

Water samples were taken prior to sediment coring at site PG1755 in the central part of the lake and at site PG1756 at the northern end of the lake. The water samples were taken from the water column at 100-cm intervals with a 50 cm long UWITEC water sampler, which is released by a short uplift in a certain depth and contains two litre of water. The water sampler also was equipped with a thermometer. Aliquots (about 250 ml) of the water samples immediately were measured in the camp, using a WTW-OXI-92 probe for oxygen contents, a WTW-LF-96 probe for conductivity, and a HANNA-MI-8314 probe for pH values. The remaining water samples were stored in 60-ml Nalgene bottles for later anion and cation analyses in the AWI laboratory at AWI Potsdam. Two alliquots were prepared, respectively, one in its original state and a second one, which was squeezed through a 0.45-µm filter.

1.4.3 Sediment coring

Sediment coring was carried out with two different coring systems. A detailled explanation of both coring methods is given in Melles et al. (1994). An UWITEC gravity corer, equipped with a 6 cm wide and 60 cm long PVC liner, was used for the undisturbed retrieval of the uppermost water-rich lake sediments. The gravity corer was lowered manually through the ice drill holes. For the deeper sediments, an UWITEC piston corer system was used, operated from a tripod that was installed on wooden planks on the lake ice cover (Figure 1-5). The tripod holds three winches with steel ropes that are connected with a 3 m long and 6 cm wide corer steel tube (including a PVC liner), a piston, and a hammer weight, respectively. During the successive penetration of the corer into the sediment, the piston of the corer was fixed on average every 250 cm, to obtain sediment cores with sufficient overlap. When starting the coring process, the piston generally was released about 50 cm above the water-sediment interface, to catch the water-sediment interface with the first core. The coring procedure was performed alternately from two ice holes that lay 20 cm apart, to avoid the recovery of disrupted sediments from the preceding coring process.

Figure 1-5: Sediment coring at Lake Billyakh with a tripod from ice, using the UWITEC Piston Corer system.

1.5 Results

1.5.1 Bathymetry

Figure 1-4 shows the distribution of sites where depth surveys were undertaken together with interpolated depth contour lines. The contour lines follow the general shape of the lake with extended shallow lake margins (<5m), particularly in the southern sector and the wide northern sector of the lake. The average water depth ranges around approximately 8 m. The deepest part of the lake basin (24 m) is restricted to the middle narrow sector of the lake, which possibly was scoured by glacial activity. Near the northernmost margin another small subbasin reaches a water depth of 8.0 m.

1.5.2 Water profiles

The results of the hydrological measurements from both the central part (PG1755) and the marginal part (PG1756) of Lake Billyakh are shown in Figure 1-6 and Table 1-1. At both sites, the water profiles show very similar features. During the expedition, an continuous temperature increase from 0.5°C in the surface waters and 3.0°C in the deeper water body is consistent with the inverse temperature gradient normally observed in cold high-latitude lakes during the winter to spring season. The conductivity varied around 40 to 45 µS/cm and indicates extreme fresh-water conditions. The pH values between 6.3 and 6.8 pointed to slightly acidic conditions in the deeper water column, and neutral conditions in the upper water column that was influenced by the ice cover. The oxygen contents decreased with depth with values between 8.6 and 4.1 mg/l, corresponding to oxygen saturations between 58% at the surface and 29% at the lake bottom. Since the hydrological properties of Lake Billyakh were determined in spring prior to the ice break-up, and not in summer during the algae growth season, it is difficult to infer a representative limnological assignment of Lake Billyakh in terms of the trophic status. However, there are some indirect indications for oligotrophic conditions, such as the presence of oxygen during the late stage of inverse winter stratification, the low macroscopic organic content in lake sediments, the deep transparency of the water column (observed qualitatively through the ice holes), the slightly acidic conditions, the presence of thick-walled and huge diatoms, and the abundance of freshwater perches and trouts.

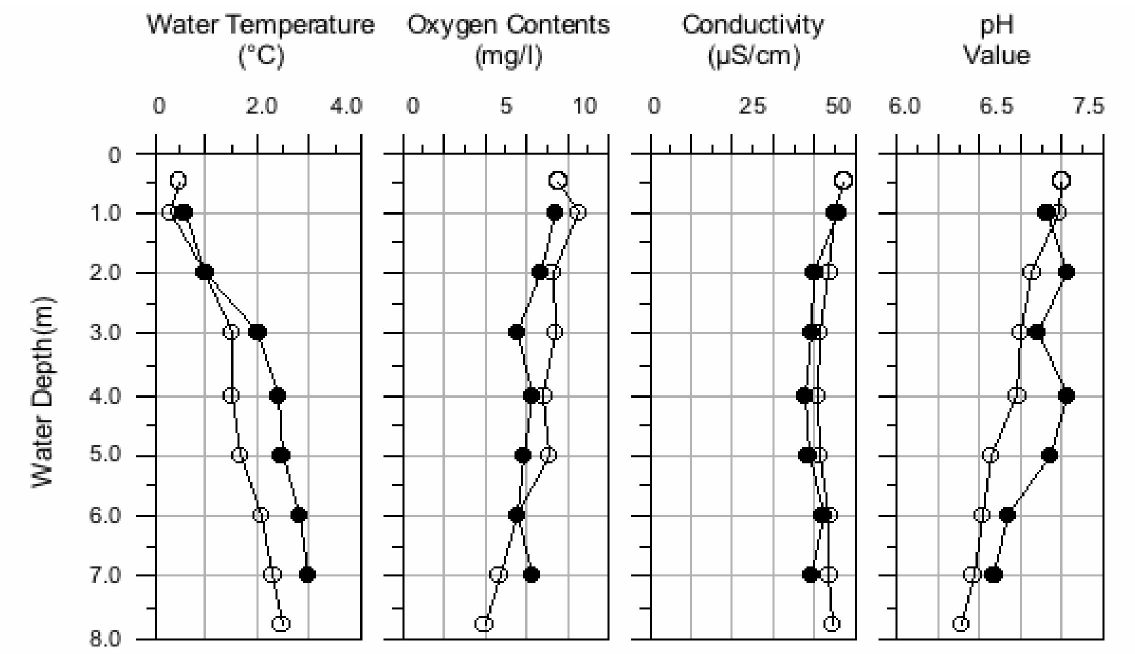


Figure 1-6: Results of water analyses from Lake Billyakh sites PG1755 (filled circles) and PG1756 (open circles).

1.5.3 Sediment Cores

The sampling of lake sediments was concentrated at one site in the central part of the lake and on a depth transect near the northern shore (Figure 1-7, Table 1.2). In summary, a total of 35 m sediment cores were taken. In the central lake, 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 section include an increased concentration of fine-grained organic gyttya in the siliciclastic muds. The first radiocarbon date indicates a Holocene age of the upper section. The lower part possibly spans the time down to at least 50 ka BP, according to the information on local glaciation history (see introduction).

Site PG1756 was cored at 7.9 m water depth in the subbasin about 800 m off the northern shore. It yielded a 6.6 m long section of greenish dark homogenous silty clays with admixtures of dispersed fine-grained gyttya. At this site, the basal sands of the lake basin were penetrated. Radiocarbon dating of the lower organic-bearing sediments indicates a Holocene age of the sediment infill.

PG1757 and PG1758 were cored 600 m and 400 m off the northern shore at 3.2 m and 2.1 m water depths, respectively. Core recovery provided a 4.8 m long section for PG1757 and a 2.8 m long sediment section for PG1758. The lithological characteristics coincide with those of the sediment cores from site PG1756. The basal sands were not encountered, because the shallow water depth for technical reasons did not allow a deeper penetration with the UWITEC coring system.

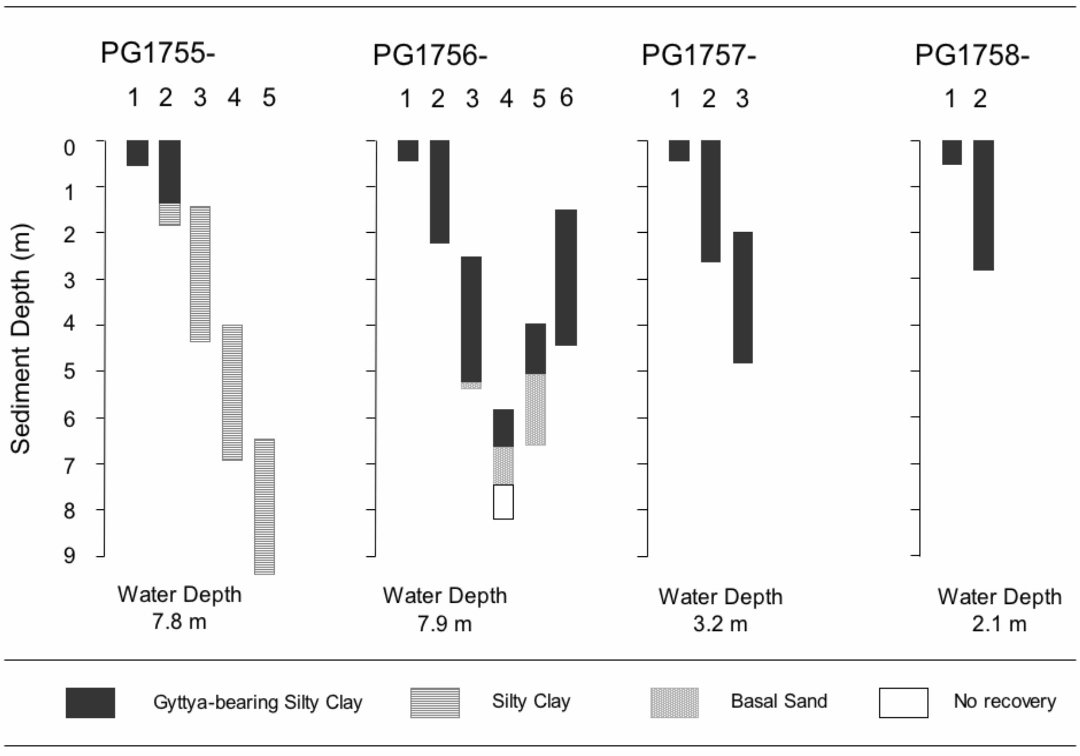


Figure 1-7: Core recovery and lithology of Lake Billyakh sediments. Core specifications are compiled in Table 1-2.

Table 1-1: Water properties at sites PG1755 and PG1756.

Site	Water Depth (m)	Temperature (°C)	Oxygen (mg/l)	Conductivity (µS/cm)	pH Value
PG1755	1.0	0.6	7.5	46.4	6.74
	2.0	1.0	6.8	40.0	6.84
	3.0	2.0	5.6	39.4	6.69
	4.0	2.4	6.3	38.2	6.83
	5.0	2.5	5.9	39.0	6.75
	6.0	2.8	5.7	42.2	6.55
	7.0	3.0	6.4	39.8	6.48
PG1756	0.5	0.5	7.6	47.7	6.80
	1.0	0.3	8.6	45.6	6.79
	2.0	1.0	7.4	43.8	6.66
	3.0	1.5	7.5	41.9	6.61
	4.0	1.5	6.9	41.3	6.59
	5.0	1.7	7.2	42.0	6.47
	6.0	2.1	5.7	43.7	6.42
	7.0	2.3	4.8	43.7	6.38
	7.8	2.5	4.1	44.3	6.32

Table 1-2: Sediment-core specifications of sites PG1755-1758.

Core	Latitude	Longitude	Water Depth (m)	Gear	Sediment Depth (m)
PG1755-1	65°16.32'N	126°44.78'E	7.8	Gravity Corer	0 - 0.50
PG1755-2	65°16.32'N	126°44.78'E	7.8	Piston Corer	0 - 1.74
PG1755-3	65°16.32'N	126°44.78'E	7.8	Piston Corer	1.50 - 4.40
PG1755-4	65°16.32'N	126°44.78'E	7.8	Piston Corer	4.00 - 6.91
PG1755-5	65°16.32'N	126°44.78'E	7.8	Piston Corer	6.50 - 9.38
PG1756-1	65°17.73'N	126°46.51'E	7.9	Gravity Corer	0 - 0.39
PG1756-2	65°17.73'N	126°46.51'E	7.9	Piston Corer	0 - 2.16
PG1756-3	65°17.73'N	126°46.51'E	7.9	Piston Corer	2.50 - 5.25
PG1756-4	65°17.73'N	126°46.51'E	7.9	Piston Corer	5.80 - 6.60
PG1756-5	65°17.73'N	126°46.51'E	7.9	Piston Corer	4.00 - 6.57
PG1756-6	65°17.73'N	126°46.51'E	7.9	Piston Corer	1.50 - 4.44
PG1757-1	65°17.79'N	126°46.52'E	3.2	Gravity Corer	0 - 0.41
PG1757-2	65°17.79'N	126°46.52'E	3.2	Piston Corer	0 - 2.60
PG1757-3	65°17.79'N	126°46.52'E	3.2	Piston Corer	2.00 - 4.83
PG1758-1	65°17.82'N	126°46.56'E	2.1	Gravity Corer	0 - 0.47
PG1758-2	65°17.82'N	126°46.56'E	2.1	Piston Corer	0 - 2.80

1.6 Outlook

Although hampered by a lot of technical problems, the expedition was very successful, as it was possible for the first time to gain a lacustrine sediment record older than Allerød from Central Yakutia. Also the Holocene sections are of high value, as they document palaeolimnological changes in a possibly oligotrophic setting, which can be compared with the palaeoenvironmental signals in the Holocene lake sediments from the highly eutrophic thermokarst lakes of the same latitude. The recovered sediment cores will be studied by a multi-proxy approach. Pollen analyses are used for the reconstruction of regional vegetation history and climate. Chironomids will provide information on palaeo July temperatures and palaeoecological changes. Diatoms will be determined for the reconstruction of palaeoecological conditions and lake history. A major issue will be the characterization and provenance analysis of the detrital sediment fraction to infer changes in riverine runoff and lake-level fluctuations. High-resolution logging data from colour scanning, XRF scanning, and physical properties (bulk density, magnetic susceptibility) help to gain insights into short-term environmental changes at millennial to centennial time scales. Preliminary data on magnetic susceptibility yield a high variability of sediment composition in the Weichselian section of PG1755, which might be promising for the recognition of potential Dansgaard-Oeschger-like climate events in Yakutia.

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The authors are indebted to the colleagues that are involved in the Verkhoyansk project and did not participate in field work: Prof. Dr. A.N. Alekseev (Rector of Yakutsk University), Prof. Dr. Andrei Prokopiev (Yakutsk University), Dr. Innokenty Beloyubsky (Yakutsk University), Margarita Gearsimova (University Yakutsk), Dr. Valentin Spektor (Permafrost Institute Yakutsk), Prof. Dr. Hans-Wolfgang Hubberten (Head of AWI Potsdam), Dr. Christine Siegert (AWI Potsdam), Dr. Larisa Nazarova (AWI Potsdam), Dr. Steffen Popp (AWI Potsdam), Prof. Dr. Frank Lehmkuhl (RWTH Aachen), Dr. Georg Stauch (RWTH Aachen), Prof. Dr. Wolfgang Zech (University Bayreuth). They all encouraged us to investigate Lake Billyakh and supported us with their special expertise on the study area. Moreover, the mentioned Russian colleagues from Yakutsk substantially helped us with the logistical preparation of field work. We also acknowledge the helping hands of the helicopter crews and of our congenial field guide, Dmitry Gruznykh. The expedition was funded by AWI Potsdam in the scope of the POL6 research programme, dealing with the Quaternary palaeoclimate in the polar regions.

1.7 References

Diekmann, B., Kumke, T., Andreev, A.A., Popp, S., Stachura-Suchoples, K., Pestraykova, L., Subetto, D. (2005). Lake record of environmental changes and palaeoclimate in eastern Siberia. Terra Nostra, Heft 2005 (2): 11-12.

Kind, N.V. (1975). Glaciations in the Verkhoyansk Mountains and their place in the radiocarbon geochronology of the Siberian Late Anthropogene. Biuletyn Peryglacjalny 24: 41-54.

Melles, M., Kulbe, T., Overduin, P.P. and Verkulich, S. (1994). The expedition Bunger Oasis 1993/94 of the AWI Research Unit Potsdam. Berichte zur Polarforschung 148: 29-80.

Popp, S., Diekmann, B., Meyer, H., Siegert, C., Syromyatnikov, I. and Hubberten, H.-W. (2006). Palaeoclimate signals as inferred from stable-isotope composition of ground ice in the Verkhoyansk foreland, Central Yakutia. Permafrost and Periglacial Processes 17: 119-132.

Popp, S., Diekmann, B., Lehmkuhl, F., Stauch, G., Siegert, C., Prokopiev, A., Belolyubsky, I. and Spektor, V. (submitted). Sediment provenance of late Quaternary morainic, fluvial, and loess-like deposits in the southwestern Verkhoyansk Mountains (eastern Siberia) and implications for regional palaeoenvironmental reconstructions. Geological Journal.

Stauch, G. (2006). Jungquartäre Landschaftsentwicklung im Werchojansker Gebirge, Nordost-Sibirien. PhD Thesis, RWTH Aachen, 191 pp.

Stauch, G., Lehmkuhl, F. and Frechen, M. (in press). Luminescence chronology from the Verkhoyansk Mountains, northeastern Siberia. Quaternary Geochronology.

Werner, K. (2006). Palynologische Untersuchungen eines Torfprofils im Vorland des Werchojansker Gebirges: Ein Beitrag zur holozänen Vegetationsgeschichte Nordostsibiriens. Diploma Thesis, University Potsdam, 99 pp.

Wetterich, S., Herzschuh, U., Pestryakova, L., Daibanyrova, M. and Ksenofontova, M. (2006). Limnological studies in central and northeast Yakutia in summer 2005. This Volume.

Zamoruyev, V. (2004). Quaternary glaciation of north-east Asia. In: Ehlers, J. and Gibbard, P.L. (eds.). Quaternary glaciations – extent and chronology, part III. Elsevier, Amsterdam, pp. 321-323.

2. Limnological studies in Central and North-east Yakutia in summer 2005

Sebastian Wetterich, Ulrike Herzschuh, Lyudmila Pestryakova, Mariya Daibanyrova and Marta Ksenofontova

2.1 Introduction

Thermokarst is a common phenomenon of the cryolithozone caused by extensive melting processes of ground ice in the underlying permafrost. Thermokarst processes are responsible for the formation of depressions in the landscape surface (Alasses), which are often occupied by so called thermokarst lakes. These well-investigated landscape forms are typical for Central Yakutia (e.g. Savvinov et al., 2005).

The main task of our fieldwork in summer 2005 in Yakutia was the sampling of surface sediment and water in thermokarst lakes and other water basins of the area, to obtain material for the investigation of paleo-bioindicators such as pollen, diatoms, chironomids and ostracods. The investigations of the recent conditions (e.g. climate, vegetation, hydro-chemistry and sediments) in the lakes allow the quantification of environmental factors, which control the recent occurrence of these indicator organisms. In future, these recent limnological studies can be useful for interpretations of data from lake sediment cores and also for quantitative paleoenvironmental reconstructions of the region.

The summer excursion in Central Yakutia was undertaken in July by a joint German-Yakutian team from AWI Potsdam (Ulrike Herzschuh, Sebastian Wetterich) and Yakutsk State University, Department of Ecology (Lyudmila Pestryakova, Mariya Daibanyrova, Marta Ksenofontova and Praskovya Kharlampeva). In August, the fieldwork was continued by Frank Kienast and Sebastian Wetterich (AWI Potsdam) in the Momskii region in North-east Yakutia.

2.2 Study sites and lake types

In July, limnological investigations were performed in Central Yakutia in 12 lakes around Yakutsk and in 27 lakes on the Lena-Amga-interfluve east of Yakutsk (Figure 2-1; Appendix 2-1). The studied lakes are situated on denudation plains and different levels (flood plains and terraces) of the Lena River: Yakutsk level, Bestyakh level, Abalakh level and Magan level (Ivanov, 1984). To infer the influence of thermokarst development on the life conditions of indicator organisms, we studied lakes according to different thermokarst stages in several geomorphological units. The classification of these lakes comprises after Solov'ev (1959) the stages: Dyuedya (initial thermokarst), Tyympy (first stage of Alas development) and mature Alas Lake. Other lakes studied in Central Yakutia were thermoerosion lakes, old branches of the Lena River and one Tukulan (dune) lake (Appendix 2-2).

The second study area was located near the village Khonuu in the mountainous Momskii region (Momskii ridge), on the estuary of the Moma River into the

Indigirka River in North-east Yakutia (Figure 2-1). In August, 16 lakes and old branches on the flood plain and the lower terraces of the Indigirka and the Moma Rivers were investigated in this region. Furthermore, Kerdyugen ponds (ponds in areas of burned forests) as well as lakes in Lowland depressions and anthropogenic water basins were studied. One lake was situated in the mountains of the Momskii Ridge (Appendix 2-1; Appendix 2-2).

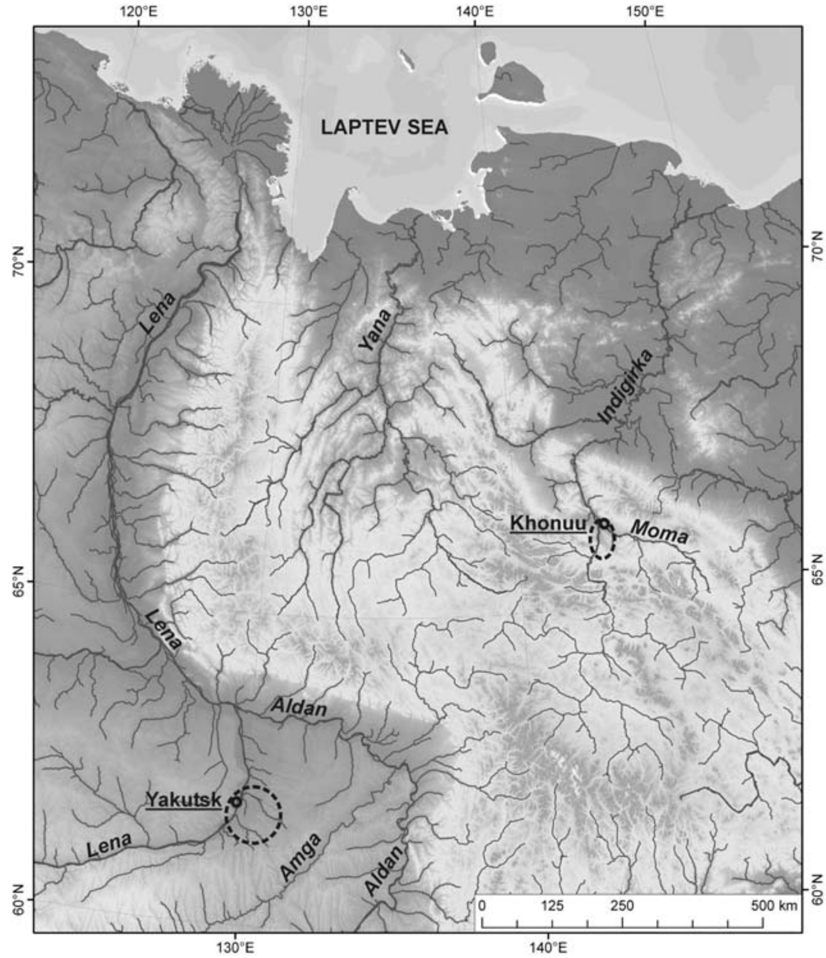

Figure 2-1: Study areas during the fieldwork in summer 2005 in Central Yakutia (Yakutsk region and Lena-Amga-Interfluve) and in North-east Yakutia (Momskii region, near the village Khonuu) (Map compiled by G. Grosse using data from GLOBE task team, 1999)

2.3 Material and methods

Investigations on properties of water chemistry and physics in the lakes were undertaken in order to describe the recent life conditions for organisms. Our investigations included the measurement of water depth by an echo sounder and water transparency by a Secchi disc (Appendix 2-2). Furthermore, we quantified pH, concentration of oxygen, electrical conductivity (salinity) and temperature using a WTW® pocket meter. In August, measurements on oxygen concentrations were continued using a titrimetric test kit (Aquamerck®), whereas pH and electrical conductivity were measured by WTW® pocket meters. The determination of total hardness, alkalinity and acidity was performed on means of titrimetric test kits (Viscolor®). For analyses in laboratory surface water was sampled from each lake (Appendix 2-3). Additionally, bottom water samples were taken in two lakes at depths of 3.2 m (05-Yak-10-3.2 m) and 4.0 m (05-Yak-28-4.0 m). Samples for cation analyses (15 ml) were acidified with 200 µl HNO3, whereas samples for anion analysis and residue samples were cool stored. Before conservation, samples for cation and anion analyses were filtered by a cellulose-acetate filtration set (pore size 0.45 µm). Additionally, water samples for δ18O and δD isotope analyses (30 ml) were preserved without any conservation and to samples for δ13C isotope analysis (30 ml) 90 µl HgCl2 were added.

Surface sediments of the lakes were sampled for sedimentological and paleontological analyses in the lake centres and near the lake shore using a Russian sediment grab. Samples for Pollen and Diatom analysis were taken in the lake centres by means of an UWITEC® gravity corer. The upper two centimetres of any obtained short core were used for these purposes. Furthermore, seven short cores were already completely subsampled in field and five short cores were stored in plastic tubes (Appendix 2-3).

Living organisms were quantitative and qualitative sampled from the water column (phytoplankton and zooplankton) and surface sediments (zoobenthos in general as well as ostracods). Phytoplankton samples were taken using a 5 µm mesh size net. About 1.5 litres were filtered through the net and the filter residue was fixed with 10% formalin. Zooplankton organisms were also sampled using a 105 µm meshsize net. About 50 – 100 litres were passed through the net and afterwards the filter residue was fixed with 10% formalin. Representatives of zoobenthos communities were picked up in surface sediment samples obtained by the Russian sediment grab from different biotopes in the lake centres and shores and afterwards preserved in 70% alcohol or 10 % formalin. The ostracods were caught in surface sediment samples from different lake zones using an exhaustor system (Viehberg, 2002) and preserved in 70 % alcohol. The qualitative composition of aquatic macrophyte vegetation was investigated and single specimens were collected for $\delta^{13}C$ isotope and n-alkane analyses.

2.4 Preliminary results

In total, 56 water basins on several terraces of the Lena, the Moma and the Indigirka Rivers have been studied (Appendix 2-1; Appendix 2-2).

The gradients of pH include data between 6.08 and 10.24 (Figure 2-2). Most samples in Central Yakutia (Yakutsk region and Lena-Amga-interfluve) show basic pH values of around pH 8 and higher. In the Momskii region the pH of lake waters seems to be generally lower in a neutral range with one exception (05-Yak-56). The highest variation in pH values was observed in lakes on the Lena-Amga-interfluve. The values for electrical conductivity range between 0.06 and 5.71 mS/cm (Figure 2-2), respectively the salinity ranges between 0 and 3.4 ‰. Higher conductivities of about 1 mS/cm and more were observed in Central Yakutian waters. The electrical conductivity of waters in the Momskii region is always below 1 mS/cm. As it is shown in Figure 2-3 the acidity of the lake waters does not reach values above 1 mmol/l in all studied lakes. The alkalinity shows a wide range from 0.6 mmol/l up to more than 28 mmol/l. However, in lakes of the Momskii region alkalinity values are generally low and range below 5.6 mmol/l.

The occurrence of different zoobenthos organisms in the lakes, sampled in July 2005 in Central-Yakutia by M. Daibanyrova is shown in Appendix 2-4.

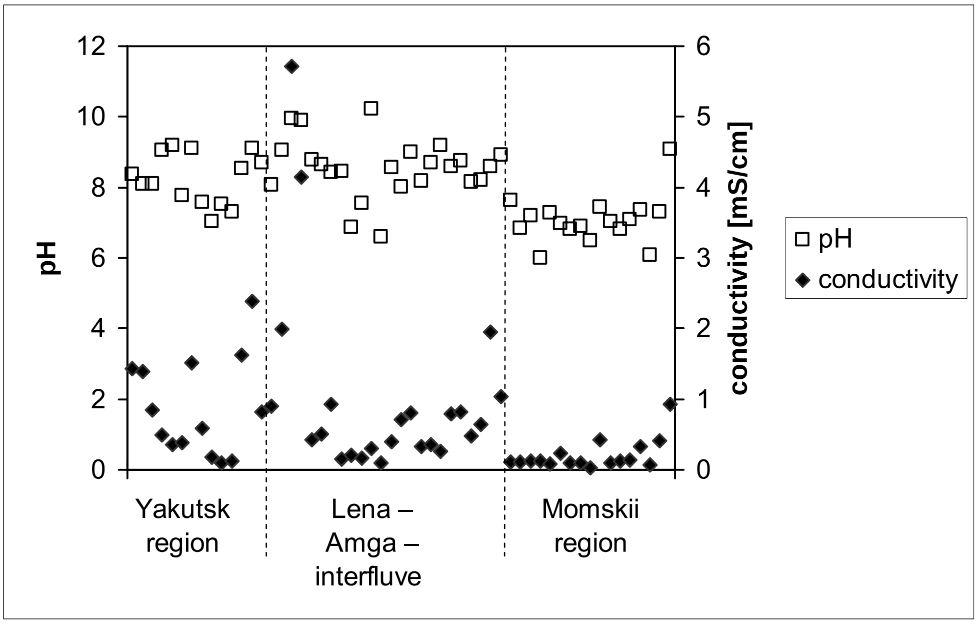

Figure 2-2: Ranges of pH and electrical conductivity in surface water samples in the study areas

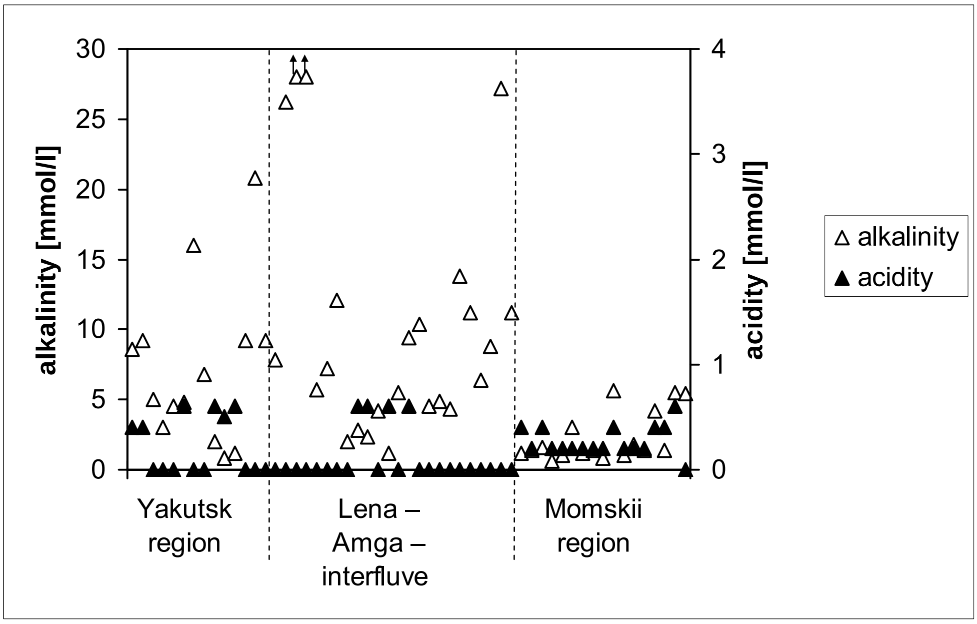

Figure 2-3: Ranges of alkalinity and acidity in surface water samples in the study areas; the arrows on alkalinity data points indicate values above 28 mmol/l

2.5 Outlook

Pollen, diatoms and ostracods will be investigated to illuminate their relationship to environmental factors such as temperature, pH and conductivity. This information will later be applied to fossil assemblages, obtained from lake sediment cores and permafrost deposits, in order to infer quantitative environmental changes via organism-environment transfer-functions.

The sampled zooplankton species (especially cladocera) from the water column and zoobenthos species (especially chironomids) from the surface sediments will be identified.

In laboratory, water samples will be analysed for element content by means of an ICP-OES and anion content by Ion Chromatography. Furthermore, analyses of δ18O and δD as well as of δ13C isotopes on water samples will be performed in order to compare these data with isotope values in calcareous ostracod valves. The understanding of the recent relationship between isotope ratios in waters and in ostracod valves will lead to an interpretation tool for paleoenvironmental information preserved in fossil ostracods. For the same purpose trace element analyses (e.g. Ca, Mg, Sr) in waters and ostracod valves will be undertaken.

On surface sediment samples analyses of nitrogen, organic and total carbon contents by CN-Analyser as well as grain-size distribution by Laser-Granulometry will be carried out in order to characterise the sedimentological setting of the investigated lakes.

Acknowledgements

The authors would like to thank their colleagues, who helped to perform a successful field campaign: Nikolai Bosikov (Permafrost Institute Yakutsk), Praskov'ya Gogoleva (Yakutsk State University), Yakov Ambros'ev (Driver in July) and Innokentii Fedorov (Khonuu, Momskii National Nature Park).

2.6 References

Ivanov, M.S. (1984). Kriogennoe stroenie chetvertichnykh otlozhenii Leno-Aldanskoi vpadiny (Cryogenic composition of Quaternary sediments of the Lena-Aldan-interfluve). Novosibirsk, Nauka. 124 pp. (original in Russian)

GLOBE Task Team (1999). The global Land one–kilometer base elevation (GLOBE) digital elevation model, version 1.0. Boulder CO: NOAA, National Geophysical Data Center.

Savvinov, D.D., Mironova, S.I., Bosikov, N.P. Anisimova, N.P., Averenskii, A.I., Gavril'eva, L.D., Gogoleva, P.A., Dmitriev, A.I., Zhirkov, F.H., Isaev, A.P., Kapitonov, A.N., Kilibeeva, O.N., Larionov, A.G., Lytkina, L.P., Mordosov, I.I., Pesterev, A.P., Pestryakova, L.A., Prokop'ev, N.P., Pshennikova, E.V., Revin, Y. V., Sobakina, I.G., Sokolova, V.A., Skryabina N.D., Tarabukina, V.G and Timofeev, P.A. (2005). Alasnye ekosistemy – struktura, funktsionirovanie, dinamika (Alas ecosystems – structure, functionality, dynamics). Novosibirsk, Nauka. 260 pp. (original in Russian)

Solov'ev, P.A. (1959). Kriolitozona severnoi chasti Leno-Amgiskogo mezhdurech'ya. (The cryolithozone of the northern part of the Lena-Amga-interfluve). Moscow, Soviet Academy of Science Publishers. 144 pp. (original in Russian)

Viehberg, F.A. (2002). A new and simple method for qualitative sampling of meiobenthos-communities. Limnologica 32: 350-351.

2.7 Appendices

Appendix 2-1: General characteristics and geographical position of the studied lakes in Central and North-east Yakutia

Appendix 2-2: Some properties of the studied lakes in Central and North-east Yakutia, obtained during the fieldwork (unfilled table cells imply no data or information)

Appendix 2-3: Sample list for further analyses on sediments, hydro-chemistry, water isotopes and aquatic organisms

Appendix 2-4: Occurrence of zoobenthos organisms in the sampled Central-Yakutian Lakes (05-Yak-01 to 05-Yak-30) in July 2005

Appendix 2-1: General characteristics and geographical position of the studied lakes in Central and North-east Yakutia

№	Lake №	Name	Region	Site	Latitude °N	Longitude °E	Elevation [m, a.s.l.]	Geo-morphology
1	05-Yak-01	B-4	Lena-Amga-interfluve	Yukechi	61°45'39,6"	130°28'15,6"	213	Abalakh level
2	05-Yak-02	B-5	Lena-Amga-interfluve	Yukechi	61°45'36,0"	130°28'19,2"	213	Abalakh level
3	05-Yak-03	B-6	Lena-Amga-interfluve	Yukechi	61°45'39,6"	130°28'26,4"	233	Abalakh level
4	05-Yak-04	Yukechi	Lena-Amga-interfluve	Yukechi	61°45'54,0"	130°27'55,9"	209	Abalakh level
5	05-Yak-05	Kh (X)	Lena-Amga-interfluve	Yukechi	61°46'11,1"	130°28'07,4"	215	Abalakh level
6	05-Yak-06	Choktokhoi	Lena-Amga-interfluve	Nizhnii Bestyakh	62°06'13,3"	130°13'21,6"	130	Bestyakh level
7	05-Yak-07	Chai-Kyuel'	Lena-Amga-interfluve	Nizhnii Bestyakh	62°01'00,1"	130°03'57,1"	138	Bestyakh level
8	05-Yak-08	Kubalakh	Yakutsk region	Vilyuskii trakt	62°03'60,5"	129°03'23,4"	228	Magan level
9	05-Yak-09	40 km Lake	Yakutsk region	Vilyuskii trakt	62°03'28,9"	129°03'13,9"	228	Magan level
10	05-Yak-10	Oibon	Lena-Amga-interfluve	Chyuya	61°42'11,4"	129°22'11,1"	160	Abalakh level
11	05-Yak-11	Kyunde	Lena-Amga-interfluve	Chyuya	61°36'50,4"	130°42'12,6"	182	Abalakh level
12	05-Yak-12	Kytyyia	Lena-Amga-interfluve	Chyuya	61°37'06,6"	130°42'28,1"	172	Abalakh level
13	05-Yak-13	Khochyma	Lena-Amga-interfluve	Nakhara	61°33'26,0"	130°32'48,3"	219	Magan level
14	05-Yak-14	Argaa-Bere	Lena-Amga-interfluve	Nakhara	61°34'06,0"	130°33'59,2"	203	Magan level
15	05-Yak-15	Magan-Sygykh	Lena-Amga-interfluve	Nakhara	61°34'20,7"	130°36'42,7"	198	Magan level

Appendix 2-1: Continuation

№	Lake №	Name	Region	Site	Latitude °N	Longitude °E	Elevation [m, a.s.l.]	Geo-morphology
16	05-Yak-16	Ochugui-Kengerime	Lena-Amga-interfluve	Nakhara	61°24'13,4''	130°33'10,8''	224	Magan level
17	05-Yak-17	Balybyrbym	Lena-Amga-interfluve	Nakhara	61°33'09,3''	130°51'34,0''	234	Magan level
18	05-Yak-18	no name	Lena-Amga-interfluve	Nakhara	61°33' 01,5''	130°53'11,7''	211	Magan level
19	05-Yak-19	Toiogoi	Lena-Amga-interfluve	Nakhara	61°24'26,0''	131°07'01,7''	250	Magan level
20	05-Yak-20	no name	Lena-Amga-interfluve	Nakhara	61°32'45,3''	130°54'18,9''	230	Magan level
21	05-Yak-21	no name	Lena-Amga-interfluve	Maralaiy	62°00' 11,3''	131°49'06,1''	208	Magan level
22	05-Yak-22	no name	Lena-Amga-interfluve	Maralaiy	62°00'23,7''	131°43'10,0''	207	Magan level
23	05-Yak-23	no name	Lena-Amga-interfluve	Maralaiy	62°07'54,2''	131°13'24,9''	169	Magan level
24	05-Yak-24	no name	Lena-Amga-interfluve	Maralaiy	61°58'05,7''	132°14'49,7''	182	Magan level
25	05-Yak-25	no name	Lena-Amga-interfluve	Maralaiy	61° 48'05,9''	132°04'58,8''	198	Magan level
26	05-Yak-26	no name	Lena-Amga-interfluve	Maralaiy	61°54'09,9''	132°12'22,1''	187	Magan level
27	05-Yak-27	no name	Lena-Amga-interfluve	Maralaiy	61°53'24,2''	132°09'51,3''	200	Magan level
28	05-Yak-28	no name	Lena-Amga-interfluve	Maralaiy	61°56'23,9''	132°09'55,8''	171	Magan level
29	05-Yak-29	N'ukulku	Lena-Amga-interfluve	Maralaiy	61°56'46,5''	132°08'39,2''	207	Magan level
30	05-Yak-30	Malyi Chabyda	Yakutsk region	15 km west of Yakutsk	61°57'60,9''	129°24'51,2''	200	Magan level

Appendix 2-1: Continuation

№	Lake №	Name	Region	Site	Latitude °N	Longitude °E	Elevation [m, a.s.l.]	Geo-morphology
31	05-Yak-31	no name	Yakutsk region	Yakutsk town	62°00'11,7''	129°35'57,8''	102	Yakutsk level
32	05-Yak-32	no name	Yakutsk region	Yakutsk town	62°00'13,7''	129°35'58,8''	104	Yakutsk level
33	05-Yak-33	Oi-Bes	Yakutsk region	Novaya Tabaga	61°50'57,8''	129°34'10,2''	111	Yakutsk level
34	05-Yak-34	Kapetovka	Yakutsk region	Kangalassy	62°18'22,8''	129°54'29,0''	96	Yakutsk level
35	05-Yak-35	Neleger	Yakutsk region	Neleger	62°19'00,7''	129°30'20,3''	182	Magan level
36	05-Yak-36	Sordakh	Yakutsk region	Neleger	62°19'03,7''	129°32'58,2''	217	Magan level
37	05-Yak-37	no name	Yakutsk region	Neleger	62°18'35,7''	129°31'18,9''	218	Magan level
38	05-Yak-38	Ulakhan	Yakutsk region	Neleger	62°20'02,2''	129°34'50,1''	200	Magan level
39	05-Yak-39	no name	Yakutsk region	Neleger	62°19'39,2''	129°33'43,2''	210	Magan level
40	05-Yak-40	Sordonno	Momskii region	Khonuu	66°20'57,7''	143°23'42,9''	220	Moma terrace
41	05-Yak-41	no name	Momskii region	Khonuu	66° 20' 57,4''	143°23'37,1''	223	Moma terrace
42	05-Yak-42	no name	Momskii region	Khonuu	66°28'33,7''	143°15'01,9''	210	Moma terrace
43	05-Yak-43	no name	Momskii region	Momskii Khrebet	66°31'05,2''	143°45'26,0''	768	Momskii Khrebet
44	05-Yak-44	no name	Momskii region	Sobolokh	66°27'22,6''	143°15'27,3''	205	Moma terrace
45	05-Yak-45	no name	Momskii region	Sobolokh	66°26'57,8''	143°16'00,0''	203	Moma terrace

Appendix 2-1: Continuation

№	Lake №	Name	Region	Site	Latitude °N	Longitude °E	Elevation [m, a.s.l.]	Geo-morphology
46	05-Yak-46	Kondoi	Momskii region	Sobolokh	66°16'34,2''	143°18'49,1''	220	Indigirka terrace
47	05-Yak-47	Marfa	Momskii region	Sobolokh	66°17'11,2''	143°18'48,4''	224	Indigirka terrace
48	05-Yak-48	Sordonnokh	Momskii region	Sobolokh	66°00'54,4''	143°12'40,4''	270	Indigirka terrace
49	05-Yak-49	Aryktaakh	Momskii region	Sobolokh	66°11'44,9''	143°20'49,5''	240	Indigirka terrace
50	05-Yak-50	Alyy	Momskii region	Sobolokh	66°13'18,2''	143°23'13,5''	235	Indigirka terrace
51	05-Yak-51	Sturuktaakh	Momskii region	Sobolokh	66°14'44,2''	143°19'18,2''	222	Indigirka terrace
52	05-Yak-52	no name	Momskii region	Khonuu	66°26'22,2''	143°17'20,1''	217	Moma terrace
53	05-Yak-53	no name	Momskii region	Khonuu	66°26'46,4''	143°16'24,4''	203	Moma terrace
54	05-Yak-54	no name	Momskii region	Khonuu	66°29'14,3''	143°13'23,8''	203	Moma terrace
55	05-Yak-55	no name	Momskii region	Khonuu	66°28'19,8''	143°15'21,2''	211	Moma terrace
56	05-Yak-56	no name	Momskii region	Khonuu	66°27'23,1''	143°14'05,4''	199	Moma terrace

Appendix 2-2: Some properties of the studied lakes in Central and North-east Yakutia, obtained during the fieldwork (unfilled table cells imply no data or information)

№	Sample №	O_2 [mg/l]	Surface water T [°C]	Sky covering [%]	Max. Water depth [m]	Sample depth (sediment) [m]	Secchi depth [m]	Lake type	Lake size [m x m]
1	05-Yak-01	3,9	24,3	10	1,8	1,8		Dyuedya	20 x 30
2	05-Yak-02	9,5	26,3	10	3,5	1,5	0,9	Dyuedya	60 x 100
3	05-Yak-03	6,5	26,1	100	4,6	3,6	1,5	Dyuedya	80 x 80
4	05-Yak-04	7,6	24,2	100	1,8	1,8	1	Alas lake	40 x 250
5	05-Yak-05	9,1	24,4	100	4,6	3,5	1,1	Tyympy	100 x 300
6	05-Yak-06	5,7	18,7	100	1,3	1,0	0,7	Lowland depression	300 x 400
7	05-Yak-07	14,5	21,0	0	1,0	0,7	0,5	Lowland depression	400 x 700
8	05-Yak-08	7,5	20,5	0	1,5	1,3	0,3	Alas lake	400 x 800
9	05-Yak-09	6,1	19,5	rain	2,2	2,1	0,7	Alas lake	200 x 300
10	05-Yak-10	9,8	21,8	rain	5,2	3,2	~0,5	Alas lake	80 x 150
11	05-Yak-10-3,2 m	1,5	13,8	rain	5,2	3,2	~0,6	Alas lake	80 x 150
12	05-Yak-11	7,6	21,9	rain	5,2	3,0	0,15	Alas lake	200 x 350
13	05-Yak-12	8,5	21,4	rain	3,0	2,0	0,35	Alas lake	no data
14	05-Yak-13	12,0	21,7	rain	3,9	2,0	0,25	Thermo-erosion lake	200 x 600
15	05-Yak-14	9,2	24,6		1,9	1,6	0,3	Thermo-erosion lake	100 x 300
16	05-Yak-15	5,8	22,9	100	1,6	1,5	0,4	Thermo-erosion lake	80 x 300
17	05-Yak-16	19,9	21,3	rain	1,5	1,2	0,4	Thermokarst lake	150 x 400
18	05-Yak-17	2,4	20,2	100	1,6	1,5	0,6	Thermokarst lake	40 x 350
19	05-Yak-18	13,7	21,5	100	1,5	1,3	0,15	Thermo-erosion lake	no data
20	05-Yak-19	1,0	22,9	100	1,3	1,1	1	Alas lake	50 x 150
21	05-Yak-20	13,3	22,6	rain	2,0	1,4	0,8	Thermo-erosion lake	400 x 800
22	05-Yak-21	7,4	20,0	rain	1,9	1,5 / 1,9	0,35	Thermo-erosion lake	100 x 200
23	05-Yak-22	22,2	20,8	rain	1,7	1,5	0,3	Thermo-erosion lake	100 x 200
24	05-Yak-23	15,7	22,8	rain	2,3	1,8	0,2	Thermo-erosion lake	150 x 350
25	05-Yak-24	38,0	21,7	10	3,2	2,3	0,25	Alas lake	200 x 300
26	05-Yak-25	no data	22,0	50	2,0	1,7 / 2,0	0,5	Alas lake	300 x 500
27	05-Yak-26	13,5	21,5	0	1,7	1,7	0,45	Alas lake	150 x 150
28	05-Yak-27	14,3	22,0	0	2,0	2,0 / 1,3	2	Alas lake	200 x 350
29	05-Yak-28	17,3	23,8	0	4,7	4,0	0,5	Tyympy	150 x 200

Appendix 2-2: : Continuation (* data from summer 2005 measured by T. Kumke)

№	Sample №	O_2 [mg/l]	Surface water T [°C]	Sky covering [%]	Max. Water depth [m]	Sample depth (sediment) [m]	Secchi depth [m]	Lake type	Lake size [m x m]
30	05-Yak-28-4,0 m	2,0	12,0	0	4,7	4,0	0,5	Tyympy	150 x 200
31	05-Yak-29	14,2	22,0	0	1,4	1,4	~0,3	Alas lake	150 x 200
32	05-Yak-30*	9,3*	16,8*	100	4,0*	0,9	1,2*	Tukulan	300 x 500
33	05-Yak-31	5,9	20,5	100		0,7		Old branch	20 x 30
34	05-Yak-32	6,8	20,2	100		0,3		Old branch	20 x 100
35	05-Yak-33	5,5	20,5	100		0,3		Old branch	30 x 300
36	05-Yak-34	6,8	18,5	80		0,3		Old branch	200 x 500
37	05-Yak-35	4,5	18,7	30		0,3		Alas lake	40 x 50
38	05-Yak-36	2,4	16,4	0		0,7		Alas lake	20 x 30
39	05-Yak-37	2,4	22,7	50		0,5		Alas lake	40 x 50
40	05-Yak-38	1,5	15,0	10		0,5		Dyuedya	30 x 200
41	05-Yak-39	5,0	16,1	0		0,7		Alas lake	100 x 100
42	05-Yak-40	4,7	17,2	100		0,7		Lowland depression	200 x 300
43	05-Yak-41	5,8	17,1	100		1,0		Lowland depression	10 x 100
44	05-Yak-42	5,4	13,7	10		0,7		Kerdyugen	20 x 30
45	05-Yak-43	5,8	11,4	10		0,8		Lowland depression	300 x 500
46	05-Yak-44	4,9	14,6	80		1,0		Anthropogenic	30 x 300
47	05-Yak-45	1,9	12,6	90		0,5		Anthropogenic	10 x 30
48	05-Yak-46	7,5	14,8	100	3,5	1,0		Old branch	20 x 1100
49	05-Yak-47	7,4	14,4	20	11,0	1,2		Old branch	30 x 1000
50	05-Yak-48	5,7	14,2	100		0,5		Old branch	30 x 250
51	05-Yak-49	4,0	13,2	100		0,5		Lowland depression	5 x 10
52	05-Yak-50	5,7	11,7	rain	1,0	0,5		Lowland depression	2 x 5
53	05-Yak-51	4,7	10,4	rain	1,0	0,5		Lowland depression	10 x 20
54	05-Yak-52	5,3	14,2	70	0,5	0,5		Lowland depression	5 x 5
55	05-Yak-53	6,9	14,3	80	1,0	0,5		Lowland depression	10 x 20
56	05-Yak-54	5,5	8,0	0	1,0	0,5		Lowland depression	10 x 30
57	05-Yak-55	4,7	16,4	0	1,0	0,5		Kerdyugen	5 x 10
58	05-Yak-56	6,2	18,9	0	1,0	0,5		Anthropogenic	10 x 200

Appendix 2-3: Sample list for further analyses on sediments, hydro-chemistry, water isotopes and aquatic organisms; short cores of lake sediments were subsampled in field (bags) or stored in liner tubes

№	Lake №	Date	Time	Sediments			Hydrochemistry			Water isotopes			Aquatic organisms			
				Lake centre	Lake shore	Short cores	Cations	Anions	Residue	δ13C	δ18O	δD	Ostra-cods	Zoo-benthos	Phyto-plankton	Zoo-plankton
1	05-Yak-01	10.07.05	10	X			X	X	X	X	X	X	4 X	X	X	X
2	05-Yak-02	10.07.05	14	X			X	X	X	X	X	X	3 X	X	X	X
3	05-Yak-03	10.07.05	20	X			X	X	X	X	X	X	4 X	X	X	X
4	05-Yak-04	11.07.05	11	X		bags	X	X	X	X	X	X	5 X	X	X	X
5	05-Yak-05	11.07.05	22	X			X	X	X	X	X	X	1 X	X	X	X
6	05-Yak-06	13.07.05	10	X		bags	X	X	X	X	X	X	4 X	X	X	X
7	05-Yak-07	13.07.05	20	X	X		X	X	X	X	X	X	4 X	X	X	X
8	05-Yak-08	15.07.05	15	X			X	X	X	X	X	X	4 X	X	X	X
9	05-Yak-09	15.07.05	19	X		bags	X	X	X	X	X	X	2 X	X	X	X
10	05-Yak-10	17.07.05	10	X	X		2 X	2 X	2 X	2 X	2 X	2 X	4 X	X	X	X
11	05-Yak-11	17.07.05	16	X			X	X	X	X	X	X	3 X	X	X	X
12	05-Yak-12	17.07.05	20	X		bags	X	X	X	X	X	X	4 X	X	X	X
13	05-Yak-13	18.07.05	13	X			X	X	X	X	X	X	3 X	X	X	X
14	05-Yak-14	18.07.05	17	X			X	X	X	X	X	X	4 X	X	X	X
15	05-Yak-15	18.07.05	21	X			X	X	X	X	X	X	4 X	X	X	X
16	05-Yak-16	19.07.05	13	X		bags	X	X	X	X	X	X	4 X	X	X	X
17	05-Yak-17	19.07.05	10	X		tube	X	X	X	X	X	X	3 X	X	X	X
18	05-Yak-18	20.07.05	15	X	X		X	X	X	X	X	X	4 X	X	X	X
19	05-Yak-19	20.07.05	19	X			X	X	X	X	X	X	4 X	X	X	X
20	05-Yak-20	20.07.05	22	X		tube	X	X	X	X	X	X	2 X	X	X	X
21	05-Yak-21	22.07.05	13	X			X	X	X	X	X	X	4 X	X	X	X
22	05-Yak-22	22.07.05	17	X		tube	X	X	X	X	X	X	3 X	X	X	X
23	05-Yak-23	22.07.05	22	X			X	X	X	X	X	X	1 X	X	X	X
24	05-Yak-24	23.07.05	13	X		bags	X	X	X	X	X	X	4 X	X	X	X
25	05-Yak-25	23.07.05	18	X			X	X	X	X	X	X	2 X	X	X	X
26	05-Yak-26	24.07.05	12	X			X	X	X	X	X	X	4 X	X	X	X
27	05-Yak-27	24.07.05	15	X		tube	X	X	X	X	X	X	4 X	X	X	X
28	05-Yak-28	24.07.05	19	X		tube	2 X	2 X	2 X	2 X	2 X	2 X	3 X	X	X	X

Appendix 2-3: Continuation

№	Lake №	Date	Time	Sediments			Hydrochemistry			Water isotopes			Aquatic organisms			
				Lake centre	Lake shore	Short cores	Cations	Anions	Residue	δ13C	δ18O	δD	Ostra-cods	Zoo-benthos	Phyto-plankton	Zoo-plankton
29	05-Yak-29	24.07.05	22	X			X	X	X	X	X	X	4 X	X	X	X
30	05-Yak-30	26.07.05	13	X		bags	X	X	X	X	X	X	2 X	X	X	X
31	05-Yak-31	31.07.05	12		X		X	X	X	X	X	X	2 X			
32	05-Yak-32	31.07.05	15		X		X	X	X	X	X	X	2 X			
33	05-Yak-33	02.08.05	13		X		X	X	X	X	X	X	2 X			
34	05-Yak-34	03.08.05	17		X		X	X	X	X	X	X	2 X			
35	05-Yak-35	04.08.05	17		X		X	X	X	X	X	X	2 X			
36	05-Yak-36	05.08.05	11		X		X	X	X	X	X	X	2 X			
37	05-Yak-37	05.08.05	17		X		X	X	X	X	X	X	2 X			
38	05-Yak-38	06.08.05	10		X		X	X	X	X	X	X	2 X			
39	05-Yak-39	06.08.05	12		X		X	X	X	X	X	X	2 X			
40	05-Yak-40	09.08.05	17		X		X	X	X	X	X	X	2 X			
41	05-Yak-41	09.08.05	19		X		X	X	X	X	X	X	2 X			
42	05-Yak-42	10.08.05	15		X		X	X	X	X	X	X	2 X			
43	05-Yak-43	13.08.05	20		X		X	X	X	X	X	X	2 X			
44	05-Yak-44	15.08.05	20		X		X	X	X	X	X	X	2 X			
45	05-Yak-45	15.08.05	22		X		X	X	X	X	X	X	2 X			
46	05-Yak-46	16.08.05	16		X		X	X	X	X	X	X	2 X			
47	05-Yak-47	16.08.05	21		X		X	X	X	X	X	X	2 X			
48	05-Yak-48	17.08.05	17		X		X	X	X	X	X	X	2 X			
49	05-Yak-49	18.08.05	12		X		X	X	X	X	X	X	2 X			
50	05-Yak-50	18.08.05	16		X		X	X	X	X	X	X	2 X			
51	05-Yak-51	19.08.05	11		X		X	X	X	X	X	X	2 X			
52	05-Yak-52	20.08.05	13		X		X	X	X	X	X	X	2 X			
53	05-Yak-53	20.08.05	16		X		X	X	X	X	X	X	2 X			
54	05-Yak-54	21.08.05	11		X		X	X	X	X	X	X	2 X			
55	05-Yak-55	21.08.05	15		X		X	X	X	X	X	X	2 X			
56	05-Yak-56	21.08.05	20		X		X	X	X	X	X	X	2 X			

Appendix 2-4: Occurrence of zoobenthos organisms in the sampled Central-Yakutian Lakes (05-Yak-01 to 05-Yak-30) in July 2005

№	Lake №	Mol-lusca	Beetles	Leechs	Chiro-nomids	Diptera larvae	Fly larvae	Trichop-tera larvae	Bugs	Anisop-tera	Ephe-mera	Gerri-dae	Spider	Amphi-poda	Others
1	05-Yak-01														
2	05-Yak-02	+	+		+			+	+	+	+		+	+	+
3	05-Yak-03	+	+	+	+		+	+	+	+			+	+	+
4	05-Yak-04	+	+	+	+		+	+	+	+		+	+	+	+
5	05-Yak-05														
6	05-Yak-06	+	+		+			+	+			+			+
7	05-Yak-07	+	+				+	+	+			+			+
8	05-Yak-08		+		+			+	+	+		+	+		+
9	05-Yak-09	+			+				+	+					
10	05-Yak-10	+	+	+	+			+	+		+	+	+	+	+
11	05-Yak-11	+			+		+	+	+	+	+	+			+
12	05-Yak-12	+	+				+			+	+				+
13	05-Yak-13	+	+	+	+			+	+	+	+	+	+		+
14	05-Yak-14	+	+	+	+		+	+	+	+	+	+	+		+
15	05-Yak-15	+	+		+	+			+	+	+	+	+		+
16	05-Yak-16		+	+	+	+		+	+	+					
17	05-Yak-17	+	+		+			+	+	+	+	+	+		+
18	05-Yak-18	+			+		+	+		+	+		+	+	+
19	05-Yak-19	+	+		+		+	+	+	+	+				+
20	05-Yak-20	+	+		+				+	+	+	+	+		+
21	05-Yak-21	+	+	+	+			+		+		+	+		
22	05-Yak-22	+	+		+			+		+				+	
23	05-Yak-23	+	+	+	+		+	+	+	+	+	+		+	+
24	05-Yak-24	+	+		+	+	+	+	+	+	+				+
25	05-Yak-25	+			+	+			+	+	+	+	+		
26	05-Yak-26	+	+	+	+	+	+		+	+	+		+		+
27	05-Yak-27		+	+	+		+	+	+	+			+	+	+
28	05-Yak-28		+		+					+			+		
29	05-Yak-29		+		+	+	+	+		+					+
30	05-Yak-30		+	+	+	+	+	+		+		+	+		

3 Vegetation studies in extremely continental regions of Yakutia

Frank Kienast, Praskov'ya Alekseevna Gogoleva

3.1 Introduction

Plant macrofossils are other important bioindicators. They are preserved, however, mainly in terrestrial deposits and exceptionally well in permafrost sediments. Studies within the frame of the DFG project „The reconstruction of Quaternary vegetation and climate in Northern Siberia using botanical macroremains preserved in Permafrost sequences", revealed remarkable correspondences between the Pleistocene plant cover in the Siberian Arctic and current vegetation and environments in climatically extremely continental regions of Central and Northeast Yakutia allowing far reaching conclusions concerning the climatic interpretation of palaeobotanical results (Kienast et al. 2005). Accordingly, plant species of the following vegetation types dominated the plant cover of the Bykovsky Peninsula, thus in today's tundra zone during the late Pleistocene.

Aquatic plants

Littoral pioneer vegetation

Wetland vegetation

Floodplain meadows including halophytes

Steppes

Arctic-alpine mats and scree pioneer vegetation

Except for arctic-alpine floral elements and wetland species, the most representatives of these communities occur considerably farther south today. Furthermore, there is another apparent common characteristic: Many of the evidenced species form, out of their main distribution in Mongolia and southern Siberia, range fragments, so-called disjunctions in the most continental parts of Yakutia. Since a genetic exchange between main and fragmentary ranges is impossible due to the large distances, these fragments are considered as parts of a primarily continuous large range. Consequently, these range fragments are Pleistocene relicts. According to Yurtsev (1982, 2001), three major areas are known within Yakutia, where, due to continentality, relict steppe vegetation is widespread and obviously persisted beyond the Pleistocene aridity peaks (compare Figure 3-1): (1) the Central Yakutian lowland, especially the Amga-Lena interfluve north to the Vilyuy River valley, (2) the highlands around the upper Yana River, including the catchments of the rivers Dulgalakh, Sartang, and lower Adycha, and (3) mountainous areas at the upper course of the Indigirka River in the Chersky and Momsky Mountains south to the area near Oymyakon.

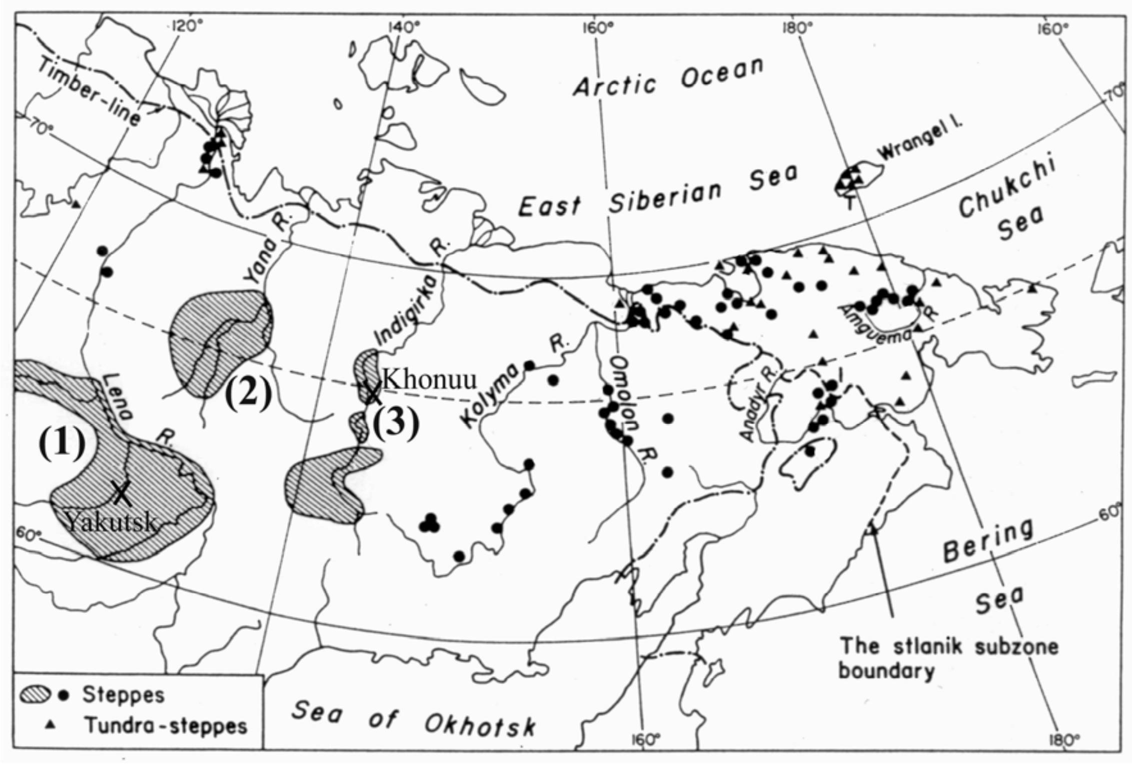

Figure 3-1: Distribution of steppe and tundra-steppe relicts in Northeast Siberia. The occurrences are disjunctive. That means they are too far away from their main range in Mongolia and South Siberia to enable genetic exchange. Thus they indicate clearly a formerly closed range during maximum continentality phases in Pleistocene. Stlanik: extensive scrublands with stone pine, birch, and poplar. From Yurtsev 1982.

In Yakutian mountain areas (Momsky, Chersky, and Yana regions), the relict steppes coexist with arctic-alpine vegetation, mainly with *Kobresia* meadows and alpine pioneer plants, in a complex that in parts resembles floristically the high arctic plant cover during Pleistocene cold stages. In the Central Yakutian lowlands, the steppes (Figure 3-2) form mosaics with floodplain meadows and salt resistant vegetation, thus with lowland communities that are heavily influenced by groundwater fluctuations and that also have an arctic counterpart in the arctic lowlands during the Pleistocene according to plant macrofossil studies at the Laptev Sea coast (Kienast et al. 2005). A ground-water surface close to the ground level and high evaporation are preconditions of salt accumulation inland, conditions that obviously existed in the Yakutian arctic during the Pleistocene.

The field campaign in summer 2005 should constitute the foundation for the ecological evaluation of the palaeobotanical results and yield more Siberian reference material for the identification of fossil plant remains. In addition to steppe and floodplain communities, which have been the main focus during the expedition in 2003, aquatic, riparian, and wetland vegetation was especially under consideration, since macrofossil assemblages are mostly deposited in wet environments, such as shallow lakes and periodically inundated depressions and are thus dominated by hydrophytes. The field work focussed on three aims:

(1) the collection of reference plant material, both diaspores and herbarium specimen

For the identification of fossil parts of plants, it is crucial to compare them with modern plant material. Seeds and fruits (diaspores) are especially well preserved in permafrost deposits. Due to their characteristic features like size, shape, color, surface structure etc., they can easily be used for the exact identification of parent plant species, in most cases even to the species level. A modern seed and fruit collection is however the precondition of palaeobotanical identifications. Other frequently found suitable plant parts are e.g. leaves, buds, parts of flowers, and scales. They can be yielded from herbarium material. Thus a herbarium is also needed for plant macrofossil identifications.

(2) studies on the composition of the relict steppe vegetation complex

Mainly the following questions should be resolved: in what a combination occur plant species in disjunctive (extrazonal) ranges? Is the species composition comparable to the species combination in the main distribution area (Dahuria, Mongolia)? Thus, can the same combination be assumed for paleo-occurrences in the arctic? Vegetation descriptions base in Russia mainly on life forms in combination with dominating plant species. The approach of using characteristic species for vegetation descriptions as it is conventional in Northern Europe (Dierßen 1996) is there still quite unusual. Therefore, vegetation descriptions from Europe and Russia are partly hardly to compare. The Yakutian relict steppes are floristically closely related to Dahurian/Mongolian steppes, which are described in detail according to the characteristic species approach (Hilbig 1990). Vegetation records in Yakutia done by ourselves shall contribute to our general understanding of Siberian relict steppe composition and enable a correlation with the European plant sociological system. Moreover, special attention shall be given to inland occurrences of halophytic vegetation, which is widespread in floodplains and thermokarst depressions of the Central Yakutian lowlands.

(3) ecological studies on floristic relations of Siberian alpine and arctic vegetation in Yakutian mountains and highlands with the relict steppes in their immediate proximity.

Species such as *Kobresia bellardii, Potentilla nivea,* and *Minuartia arctica* are known to have coexisted with steppe plants in the Siberian arctic during the Weichselian cold stage (Kienast et al. 2005). Ecological studies in regions of their current coexistence could contribute to the general understanding of the environmental conditions during cold stages.

Two major areas of Pleistocene relict vegetation, Central Yakutia and the Momsky/Cherski Mountain region, have already been the object of an expedition in the frame of a DAAD (German Academic Exchange Service) scholarship in 2003. Primarily, it was therefore planned to investigate mainly the vegetation of the Yana highlands (2 in Figure 3-1). This region is of particular importance since it is the northernmost large relict steppe area in Yakutia. Moreover it is situated closest to the palaeobotanical study sites at the arctic coast of the Laptev Sea. Unfortunately, shortly before departure, a catastrophic flooding of the Yana River and its tributaries hit the region around Verkhoyansk – the starting point of the Yana highland expedition. The region was thus no longer accessible by plane and all transport capacities were needed for emergency services. Consequently, this part of the expedition had to be given up.

Alternatively, at first part of the expedition, the vegetation in the vicinity of Yakutsk was studied in further detail due to the easy accessibility of the area. With the friendly help of the Faculty of Geobotany at the University of Yakutsk, namely Prof. Praskovya Alekseevna Gogoleva, and the administration of the Momskii National Nature Park, it was possible to organize quickly a stay in the Momsky region, the third and easternmost of the large relict steppe areas.

Figure 3-2: Steppe including *Ephedra monosperma, Allium strictum, Orostachys spinosa, Artemisia commutata, Koeleria cristata*, and *Festuca lenensis* at a steep slope of the Lena terrace (vegetation record Nr. 02.08./14, see appendix 3-1)

3.2 Study areas and investigated vegetation types

During the first part of the expedition, the vegetation at several sites in the vicinity of the capital Yakutsk in Central Yakutia was recorded. The region is characterized by arid climate conditions. Since the ground close to the groundwater table is always supported by water and solutes due to the near-surface permafrost, high evaporation results in salinization. The latter applies especially to depressions without discharge, where salt crusts frequently form at the surface and plants typical of the Sea coast occur (Fig. 3-3).

Figure 3-3: Halophyte vegetation with *Sueda corniculata, Salicornia europaea, Glaux maritima, Puccinellia tenuiflora*, and *Atriplex patens* round a puddle in Central Yakutia.

We focussed mainly on the vegetation in thermokarst depressions (alases) and relict steppes on steep, extremely dry slopes at terraces of the Lena River (Figs. 3-2 and 3-4). In alases, we were exerted to record vegetation transects from the center, filled with lakes, to the driest places at the margin. Typically, plant communities in following complex occurred along such transect: aquatics, littoral pioneers, reed communities, floodplain meadows, saline meadows, and steppes (Figure 3-4). This combination of plant communities is in parts analogous to the arctic vegetation at the Laptev Sea coast during the Pleistocene.

Only one main constituent of the Pleistocene vegetation in the Siberian Arctic was absent in Central Yakutia: arctic or respectively alpine vegetation. To study the alpine vegetation in extremely continental areas of Yakutia and its transition to steppe communities was the main focus during the stay in the Momskii region.

Since there was no transport capacity due to our rapid change of expedition planning, we could record unfortunately only two sites with alpine or respectively subalpine vegetation in the hardly accessible Momskii region (Figures 3-5 and 3-6).

Figure 3-4: Vegetational zonation at the shore of an alas-lake close to the Neleger Station in Central Yakutia. For comparison see records 05.08./1 to 05.08./7 in the appendix 3-1.

3.3. Material and methods

The vegetation of the study sites was recorded on a minimum area of the respective community (an area with uniform environmental conditions, e.g. decline, exposition, moisture etc., which contains the complete combination of all characteristic species and which is homogenous, thus which is not dominated in certain parts by differing species). Therefore, every species occurring on the minimum area was recorded on a list including its coverage or relative abundance (at low coverage), date, time, site description including substrate, soil, moisture, degree and character of disturbances, anthropogenic influence etc.

Figure 3-5: Alpine *Dryas* vegetation interspersed with steppe plants above the *Pinus pumila* belt of the Momskii Mountains about 1400 m above sea level.

Herbarium material was mostly taken especially from Siberian plants and always in the case when an exact identification was not possible in the field. The herbarium specimens were then used for subsequent identification. Photos were taken from every record and sometimes additionally from characteristic plants.

If available, fruits and seeds were collected from all plant species. They were packed in small folded paper-bags, where they could respire and, if necessary, dry. All taken plant material was certainly labeled and documented.

3.4 Preliminary results

Altogether, the vegetation of 72 sites was recorded and sampled (see appendix). Unknown plants will subsequently be identified; the vegetation records will then be supplemented with the lacking identifications. The collected seeds and fruit samples were split and made available to the following collections: AWI reference seed collection, carpological collection of the Museum of Natural history Berlin, the Botanical Garden of the Free University Berlin Dahlem, and the Botanical Garden of the University Potsdam.

Figure 3-6: Subalpine vegetation combined with steppe plants at a steep slope in the Chiba Galakhskii Mountains (foothills of the Cherskii Mountains), about 40 km from Sobolokh upstream the Indigirka River (in the background)

Acknowledgements

We would like to thank the Yakutsk State University for general support and the supply of vehicles and drivers, the Momskii National Nature Park in Khonuu, especially Innokentij Fedorov for guidance and accommodation, and Sebastian Wetterich for communication finesse.

3.5 **Appendix 3-1:** Metadata of studied vegetation records

Record №	Date/ Time	Location/ Region	Latitude °N	Longitude °E	Vegetation type	Substrate/ soil type	Soil reaction/ conductivity	Hemeroby/ disturbance	Altitudinal belt	Decline/ exposition	Hydrology
30.07./1	30.07.05 14.00	Saline puddle near Yakutsk, Central Yakutia			Salt tolerant pioneer community	Loamy sand/ Solonchak	Alkaline, saline	Very high, regularly run over by cars	planar	No decline	Fluctuating wet
31.07./1	31.07.05 13.00	Chochur-Muran, steep slope near Yakutsk, Central Yakutia, slope foot	62°00'11,7"	129°35'57,8"	Steppe	Sandy silt, Kastanozyom	Neutral to slightly alkaline	Moderate, grazing & trampling by cattle	collin	Very steep/ ESE	dry
31.07./2	31.07.05 13.30	Chochur-Muran, steep slope near Yakutsk, Central Yakutia, lower slope	62°00'11,7"	129°35'57,8"	Steppe	Sandy silt, Kastanozyom	Neutral to slightly alkaline	Moderate, grazing & trampling by cattle	collin	Very steep/ ESE	dry
31.07./3	31.07.05 14.30	Chochur-Muran, steep slope near Yakutsk, Central Yakutia, central slope	62°00'11,7"	129°35'57,8"	Steppe	Sandy silt, Kastanozyom	Neutral to slightly alkaline	Moderate, grazing & trampling by cattle	collin	Very steep/ ESE	dry
31.07./4	31.07.05 15.00	Chochur-Muran, steep slope near Yakutsk, Central Yakutia, upper slope	62°00'11,7"	129°35'57,8"	Steppe	Sandy silt, Kastanozyom	Neutral to slightly alkaline	Moderate, grazing & trampling by cattle	collin	Very steep/ ESE	dry
31.07./5	31.07.05 15.30	Chochur-Muran, steep slope near Yakutsk, Central Yakutia, slope top	62°00'11,7"	129°35'57,8"	Steppe	Sandy silt, Kastanozyom	Neutral to slightly alkaline	Moderate, grazing & trampling by cattle	collin	Very steep/ ESE	dry
02.08./1	02.08.05	Lake Oi-Bek near Novaya Tabaga, ca 35 km S of Yakutsk	61°50'57,8"	129°34'10,2"	Littoral pioneers, riparian reed	Sapropel, mud	Slightly alkaline	Slight grazing & trampling	planar	Very slight decline	Submerged fluctuating wet
02.08./2	02.08.05	Like 02.08./1, shore zone, 50m wide floodplain stripe	61°50'57,8"	129°34'10,2"	Reed, floodplain meadow	Anmoorgley	Slightly alkaline	Slight grazing & trampling	planar	Very slight decline	Fluctuating wet
02.08./3	02.08.05	Like 02.08./1, puddle, where probably ice persisted over long time in spring	61°50'57,8"	129°34'10,2"	Pioneer vegetation at muddy sites	Anmoorgley	Slightly alkaline	Slight grazing & trampling	planar	Very slight decline	Fluctuating wet
02.08./4	02.08.05	Spots within 02.08./2 with saline plants	61°50'57,8"	129°34'10,2"	Salt tolerant pioneer community	Solonchak	Alkaline, saline	Slight grazing & trampling	planar	Very slight decline	Fluctuating moist

Appendix 3-1: Continuation

Record №	Date/ Time	Location/ Region	Latitude °N	Longitude °E	Vegetation type	Substrate/ soil type	Soil reaction/ conductivity	Hemeroby/ disturbance	Altitudinal belt	Decline/ exposition	Hydrology
02.08./5	02.08.05	Like 02.08./1, floodplain, distant from the lake	61°50'57,8''	129°34'10,2''	Floodplain meadow, saline influence	Anmoorgley	Alkaline, slightly saline	Slight grazing & trampling	planar	Very slight decline	Fluctuating moist
02.08./6	02.08.05	Like 02.08./1, floodplain, distant from the lake	61°50'57,8''	129°34'10,2''	Pure *Scolochloe* stand	Anmoorgley	Slightly alkaline	Slight grazing & trampling	planar	Very slight decline	Fluctuating moist
02.08./7	02.08.05	Like 02.08./1, floodplain, farther distant from the lake	61°50'57,8''	129°34'10,2''	Floodplain meadow, saline influence	Anmoorgley	Alkaline, slightly saline	Slight grazing & trampling	planar	Very slight decline	Fluctuating moist
02.08./8	02.08.05	Like 02.08./1, floodplain, farther distant from the lake	61°50'57,8''	129°34'10,2''	Floodplain meadow, saline influence	Anmoorgley	Slightly alkaline	Slight grazing & trampling	planar	Very slight decline	Fluctuating moist
02.08./9	02.08.05	Like 02.08./8, farther distant from the lake	61°50'57,8''	129°34'10,2''	Meadow steppe	Sandy silt, kastanozyom	Neutral to slightly alkaline	Slight grazing & trampling	collin	slight, NE	dry
02.08./10	02.08.05	Like 02.08./9, farther distant from the lake	61°50'57,8''	129°34'10,2''	Disturbed steppe	Sandy silt, kastanozyom	Neutral to slightly alkaline	grazing & trampling	collin	slight, NE	dry
02.08./11	02.08.05	Like 02.08./10, old path	61°50'57,8''	129°34'10,2''	ruderal	Sand	Neutral to slightly alkaline	Heavy trampling	collin	No decline	Moderately dry
02.08./12	02.08.05	Like 02.08./11, next terrace above the floodplain	61°50'57,8''	129°34'10,2''	Steppe	Sandy silt, kastanozyom	Neutral to slightly alkaline	slight grazing & trampling	collin	slight, NE	dry
02.08./13	02.08.05	Like 02.08./12, further upslope	61°50'57,8''	129°34'10,2''	Birch forest 5-10 years after fire	Sandy silt, kastanozyom	Neutral to slightly alkaline	Very slight grazing & trampling	collin	No decline	Moderately dry to moist
02.08./14	02.08.05	Like 02.08./13, top of the terrace	61°50'57,8''	129°34'10,2''	Dry steppe	Sandy silt, kastanozyom	Neutral to slightly alkaline	Very slight grazing & trampling	collin	Steep, NE	dry
03.08./1	03.08.05	Kangalassy Mys, 50 km N of Yakutsk, bog in thermokarst depression after forest fire	62°20'	129°59'0''	Bog vegetation	Peat, histosol	Slightly acidic	no disturbances	collin	No decline	Constantly wet, emerse, water level 25 cm

Appendix 3-1: Continuation

Record №	Date/ Time	Location/ Region	Latitude °N	Longitude °E	Vegetation type	Substrate/ soil type	Soil reaction/ conductivity	Hemeroby/ disturbance	Altitudinal belt	Decline/ exposition	Hydrology
03.08./2	03.08.05	Like 03.08./1, somewhat higher, closer to the forest	62°20'	129°59'0''	Bog vegetation	Peat, histosol	Slightly acidic	no disturbances	collin	No decline	Constantly wet, emerse, water level 5-10 cm
03.08./3	03.08.05	Like 03.08./2, dry larch-pine forest	62°20'	129°59'0''	Dry larch-pine forest		Slightly acidic		collin	No decline	moist
03.08./4	03.08.05	Steppe site on a steep slope near the settlement Kangalassy	62°20'	129°59'0''	Disturbed steppe	Sandy silt	Neutral to slightly alkaline	heavy anthropogenic disturbances	collin	Steep SE	moderately dry
04.08./1	04.08.05	Alass lake near the station Neleger adjacent to a pingo, Central Yakutia	62°19' 00,7''	129°30'20,3''	aquatic	sapropel		oligohemerob	planar	No decline	Submerged to emerged
04.08./2	04.08.05	Like 04.08./1, riparian site	62°19' 00,7''	129°30'20,3''	Littoral pioneers & riparian meadow	sapropel		oligohemerob	planar	No decline	Emerged to fluctuating wet
04.08./3	04.08.05	Like 04.08./2, further uphill, floodplain	62°19' 00,7''	129°30'20,3''	Floodplain meadow	Anmoorgley		oligohemerob	planar	No decline	Fluctuating wet
04.08./4	04.08.05	Like 04.08./3, further uphill, outer floodplain, saline	62°19' 00,7''	129°30'20,3''	Floodplain meadow, saline influenced	Solonchak?	Alkaline, saline	oligohemerob	planar	No decline	Fluctuating moist
04.08./5	04.08.05	Like 04.08./4, further uphill, Pingo slope	62°19' 00,7''	129°30'20,3''	Dry meadow		Slightly alkaline	grazed	planar	Quite steep, N	Moderately dry
04.08./6	04.08.05	Like 04.08./5, top of Pingo	62°19' 00,7''	129°30'20,3''	Disturbed meadow		Neutral to alkaline	Heavily disturbed	planar	No decline	dry
04.08./7	04.08.05	Like 04.08./6, southern slope of Pingo, near ground squirrel den	62°19' 00,7''	129°30'20,3''	ruderal			Heavily disturbed, overgrazed	planar	Quite steep, S	dry

Appendix 3-1: Metadata of studied vegetation records

Record №	Date/ Time	Location/ Region	Latitude °N	Longitude °E	Vegetation type	Substrate/ soil type	Soil reaction/ conductivity	Hemeroby/ disturbance	Altitudinal belt	Decline/ exposition	Hydrology
05.08./1	05.08.05	Alass lake Sordakh Yak 36, Central Yakutia	62°19' 03,7''	129°35'58,2''	aquatic	sapropel	Alkaline, electrolyte-rich	oligohemerob	planar	No decline	Submerged to emerged
05.08./2	05.08.05	Like 05.08./1, emerged vegetation at the shore	62°19' 03,7''	129°35'58,2''	Riparian reed, emerged	sapropel	Alkaline, electrolyte-rich	oligohemerob	planar	No decline	emerged
05.08./3	05.08.05	Like 05.08./2, dry land, *Alopecurus* zone	62°19' 03,7''	129°35'58,2''	Floodplain meadow	Anmoorgley?	Alkaline, electrolyte-rich	grazed	planar	Very slight decline	Fluctuating wet
05.08./4	05.08.05	Like 05.08./3, dry land, *Elytrigia* zone	62°19' 03,7''	129°35'58,2''	Floodplain meadow		Alkaline, electrolyte-rich	Grazed by horses	planar	Very slight decline	Fluctuating moist
05.08./5	05.08.05	Like 05.08./4, dry land, farther upland	62°19' 03,7''	129°35'58,2''	Dry meadow		alkaline	Grazed by horses	planar	Very slight decline	Moderately dry
05.08./6	05.08.05	Like 05.08./5, farther upland, close to a ground squirrel midden	62°19' 03,7''	129°35'58,2''	Disturbed steppe	Silt, kastanozyom	alkaline	grazed by ground squirrel & horses	planar	Very slight decline	dry
05.08./7	05.08.05	Like 05.08./6, farther upland, next Alas terrace higher	62°19' 03,7''	129°35'58,2''	steppe	Silt kastanozyom	alkaline	grazed by ground squirrel & horses	planar	Very slight decline	Very dry
05.08./8	05.08.05	Pingo, near the Neleger station, vicinity of a ground squirrel midden			Disturbed steppe	Silt, kastanozyom	alkaline	Overgrazed by ground squirrel	planar	Unregularly declined 0-20°, SW	dry
05.08./9	05.08.05	Like 05.08./8, Pingo top, less disturbed			steppe	Silt kastanzyom	alkaline	grazed	planar	Unregularly declined 0-20°, S	dry
05.08./10	05.08.05	Like 05.08./9, Pingo foot			Shrubby steppe	Silt kastanzyom	alkaline	grazed	planar	Unregularly declined 0-20°, S	dry
05.08./11	05.08.05	Very shallow thermokarst lake Yak 37 near Neleger station	62°18' 35,7''	129°31'18,9''	Aquatic and littoral vegetation	Silt, sapropel	Alkaline, brackish	undisturbed	planar	No decline	Submerged to emerged

Appendix 3-1: Continuation

Record №	Date/ Time	Location/ Region	Latitude °N	Longitude °E	Vegetation type	Substrate/ soil type	Soil reaction/ conductivity	Hemeroby/ disturbance	Altitudinal belt	Decline/ exposition	Hydrology
05.08./12	05.08.05	Like 05.08./11, saline meadow adjacent to the shore line	62°18' 35,7''	129°31'18,9''	Saline meadow	solontchak	Alcaline, saline	Slightly grazed	planar	Slightly declined	Fluctuating wet
05.08./13	05.08.05	Like 05.08./12, *Potentilla anserina* zone	62°18' 35,7''	129°31'18,9''	Saline meadow	solontchak	Alcaline, saline	Slightly grazed	Planar	Slightly declined	Fluctuating moist
05.08./14	05.08.05	Like 05.08./13, *Hordeum brevisubulatum* zone	62°18' 35,7''	129°31'18,9''	Saline meadow	solontchak	Alkaline, saline	Slightly grazed	planar	Slightly declined	Fluctuating moist
06.08./1	06.08.05	Thermokarst lake Ulakhan Yak 38 near the Neleger station	62°20'02,2''	129°34'50,1''	aquatic	sapropel	Circumneutral, electrolyte-rich	oligohemerob	planar	flat	Submerged
06.08./2	06.08.05	Like 06.08./1, littoral	62°20'02,2''	129°34'50,1''	Littoral vegetation	mud	Circumneutral, electrolyte-rich	disturbed by fluctuating water level & trampling	planar	Slightly declined	Fluctuating wet, periodically inundated
06.08./3	06.08.05	Like 06.08./2, farther upland	62°20'02,2''	129°34'50,1''	Saline floodplain meadow		Alkaline, saline	Slightly grazed	planar	Slightly declined	Fluctuating moist
06.08./4	06.08.05	Landing lake Yak 39 with very wide (>100m wide) emerged shore	62°19'39,2''	129°33'43,2''	aquatic	sapropel	Circumneutral	undisturbed	planar	flat	submerged
06.08./5	06.08.05	Like 06.08./4, onshore, floodplain	62°19'39,2''	129°33'43,2''	Floodplain meadow	anmoorgley	circumneutral	undisturbed	planar	Very slightly declined	Regularly inundated, wet
06.08./6	06.08.05	Like 06.08./5, further upland	62°19'39,2''	129°33'43,2''	meadow			Slightly grazed	planar	Slightly declined	Fluctuating dry
09.08./1	09.08.05	Lake Sordonno Yak 40 near Khonuu, Momskii region	66°20'57,7''	143°23'42,9''	Riparian reed	Anmoorgley, quaking bog, peat?	circumneutral	undisturbed	Sub-montan	flat	Constantly wet
09.08./2	09.08.05	Like 09.08./1, on land dry littoral	66°26'22,2''	143°17'20,1''	Reed & littoral vegetation	Anmoorgley			Sub-montan	Very slightly declined	Fluctuating wet
09.08./3	09.08.05	Small lake adjacent to lake Sordonno	66°26'46,4''	143°16'24,4''	aquatic	Peat?		undisturbed	Sub-montan	flat	submerged

Appendix 3-1: Metadata of studied vegetation records

Record №	Date/ Time	Location/ Region	Latitude °N	Longitude °E	Vegetation type	Substrate/ soil type	Soil reaction/ conductivity	Hemeroby/ disturbance	Altitudinal belt	Decline/ exposition	Hydrology
09.08./4	09.08.05	Like 09.08./3, on land floodplain	66°29'14,3"	143°13'23,8"	riparian			undisturbed	Sub-montan		Fluctuating wet
09.08./5	09.08.05	Like 09.08./4, on land anthropogenic kolluvium	66°28'19,8"	143°15'21,2"	shrubbery	colluvium			Sub-montan	irregular	moist
10.08./1	10.08.05	Steppe slope near Khonuu, vice versa airport, Momskii region	66°20	143°23'	steppe	gravely loam, rendzina	Slightly alkaline	Grazed & trampled	montan	Steep (30°?), SW	dry
12.08./1	12.08.05	Ridge in the Momskii Mountains, ca 1 km SW of Belaya Gora about 1400 m a.s.l.			Alpine vegetation	gravel, rendzina	Slightly alkaline	Deflation	alpine	Top – no exposition	Very dry
15.08./1	15.08.05	Lake Yak 44 in Khonuu, Momskii region	66°27'22,6''	143°15'27,3''	aquatic	Sapropel above gravel	circumneutral	Trampling & grazing	montan	flat	submerged
15.08./2	15.08.05	Like 15.08./1, on land, riparian zone	66°27'22,6''	143°15'27,3''	Riparian reed			Trampling & grazing	montan	flat	Constantly wet
16.08./1	16.08.05	Meadow steppe near Sobolokh, at the River Indigirka, Cherskii Mountains, Momskii region	66°16'	143°18'	Meadow steppe	Sandy silt, kastanozyom	Slightly alkaline	Grazed by horses	Sub-montan	flat	dry
17.08./1	17.08.05	Steep slope at the Chiba Galakhskii Mountains (foothills of the Cherskii mountains), about 40 km from Sobolokh upstream the River Indigirka	66°00'	143°12'	Alpine steppe	Loamy gravel		Deflation, ahemerob	subalpine	Very steep >30%, WSW	Dry
17.08./2	17.08.05	Like 17.08./1, further uphill	66°00'	143°12'	Steppic alpine scree vegetation	scree		Deflation, ahemerob	subalpine	Very steep 45%, SW	dry

Appendix 3-1: Continuation

Record №	Date/ Time	Location/ Region	Latitude °N	Longitude °E	Vegetation type	Substrate/ soil type	Soil reaction/ conductivity	Hemeroby/ disturbance	Altitudinal belt	Decline/ exposition	Hydrology
18.08./1	18.08.05	Airfield Sobolokh near the River Indigirka	66°16’	143°18’	Heavily disturbed steppe	Silt, kastanozyom	Slightly alkaline	Heavily disturbed by planes, cattle trampling and grazing	Sub-montan	flat	Dry
18.08./1	18.08.05	Grazed steppe near Sobolokh	66°16’	143°18’	steppe	Silt, kastanozyom		Grazed and trampled	Sub-montan	flat	Dry
19.08./1	19.08.05	Hut roof at the Sobolokh cemetery	66°16’	143°18’	ruderal				Sub-montan	flat	Dry
19.08./2	19.08.05	Overgrazed meadow at the Sobolokh cemetery	66°16’	143°18’	meadow			Heavely grazed and trampled by horses	Sub-montan	flat	Dry
20.08./1	20.08.05	Steppe slope south of Khonuu, Moma River upstream Momskii region	66°20	143°23'	steppe	Gravely loam, Rendzina	Slightly alkaline	Slight grazing by horses	montan	Steep >20°, SW	Dry
21.08./1	20.08.05	Pond near the cemetery of Khonuu	66°27’23,1	143°14’05,4’’	Aquatic & littoral	sapropel	cicumneutral	Trampled by cattle	Sub-montan	flat	Submerged to emerged
21.08./2	20.08.05	Pond near the cemetery of Khonuu	66°27’23,1	143°14’05,4’’	Littoral & ruderal pioneers	sapropel	cicumneutral	Heavily trampled & overgrazed by cattle	Sub-montan	flat	excessively wet
21.08./3	20.08.05	Like 21.08./2, dry land	66°27’23,1	143°14’05,4’’	Saline floodplain meadow	anmoorgley	Alkaline, salinel	trampled & grazed by cattle	Sub-montan	Slightly declined	Fluctuating moist
21.08./4	20.08.05	Like 21.08./3, *Carex duriuscula* zone, on a path, around ground squirrel den	66°27’23,1	143°14’05,4’’	Meadow steppe		Alkaline slightly saline influenced	Heavily trampled & overgrazed by cattle & ground squirrel	Sub-montan	flat	dry