Expeditions in Siberia in 1998

Edited by Volker Rachold

Russian-German Cooperation
SYSTEM LAPTEV SEA 2000: The Lena Delta 1998 Expedition
Edited by Volker Rachold and Mikhail N. Grigoryev
with contributions of the participants

EURASIAN ICE SHEETS: Expedition to the lake Lyadhej-To (Polar Urals) in July-August 1998
by Wolf-Dieter Hermichen and Frank Wischer

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The Lena Delta 1998 Expedition

by the participants of the expedition

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Contents

1 Introduction

(V. Rachold, M. N. Grigoryev and M. Antonow)

Our knowledge of the Arctic climate system has been significantly improved through multi-disciplinary investigations carried out in the Siberian Arctic during previous Russian-German projects, such as THE LAPTEV SEA SYSTEM (1994-1997) and TAYMYR (1994-1997). The results are presented in a collection of papers published by Kassens et al. (in press).

Detailed climatic reconstructions of the late Quaternary and important information concerning the complex modern system were obtained and form the basis for the prediction of future climate changes. The investigations documented that the closely coupled land-ocean system of the Laptev Sea with the East Siberian hinterland and its complex connections, such as the Lena Delta, represent a key region for understanding environmental changes. Our present knowledge indicates that environmental changes in this area not only affect the Arctic Ocean but also contribute to variations in the global system.

The Project SYSTEM LAPTEV SEA 2000 is based on these results but addresses completely new scientific problems as well. The following subjects are studied:

A. Seasonal variability of modern fluxes in permafrost areas
   - balance of greenhouse gases (carbon dioxide and methane) and process studies of the methane balance
   - water and energy flux in permafrost soils
   - microbial communities and carbon dioxide flux in permafrost soils

B. Environmental reactions of the terrestrial-marine system of the Siberian Arctic during the last 100 years
   - marine environmental reactions and material balance
   - atmospheric input of radio-nuclides
   - sensibility of marine Arctic ecosystems

C. Land-ocean interactions and the influence on the sediment budget of the Lena Delta
   - environmental and climatic history of the Lena Delta
   - particle transport in the delta-shelf system

D. Terrestrial system: short- and medium-term climatic trends in the Siberian Arctic
   - terrestrial climatic signals in ice-rich permafrost deposits

E. Marine system: long-term climatic trends in the Siberian Arctic
   - causes and consequences of short- and medium-term climatic trends in permafrost regions
   - acoustic signatures of submarine permafrost

Within the framework of the project SYSTEM LAPTEV SEA 2000 the first terrestrial expedition Lena Delta 98 was carried out from 12 July to 29 August. The expedition was organized by the AWI-Potsdam in close co-operation with the Arctic and Antarctic Research Institute, St. Petersburg, the Permafrost Institute, Yakutsk, and the Lena Delta Reserve, Tiksi. A multi-disciplinary, Russian-German team of 30 scientists worked in the Lena Delta (Figure 1-1).

The scientific program of the expedition covered the terrestrial research objectives of the project SYSTEM LAPTEV SEA 2000, i.e.:

A. Seasonal variability of modern fluxes in permafrost areas (→ *Chapter 3: Modern Processes in Permafrost Affected Soils*)

C. Land-ocean interactions and the influence on the sediment budget of the Lena Delta (→ *Chapter 4: Modern Sedimentation and Environmental History of the Lena Delta*)

D. Terrestrial system: short- and medium-term climatic trends in the Siberian Arctic (→ *Chapter 5: Paleoclimate Signals of Ice-rich Permafrost*)

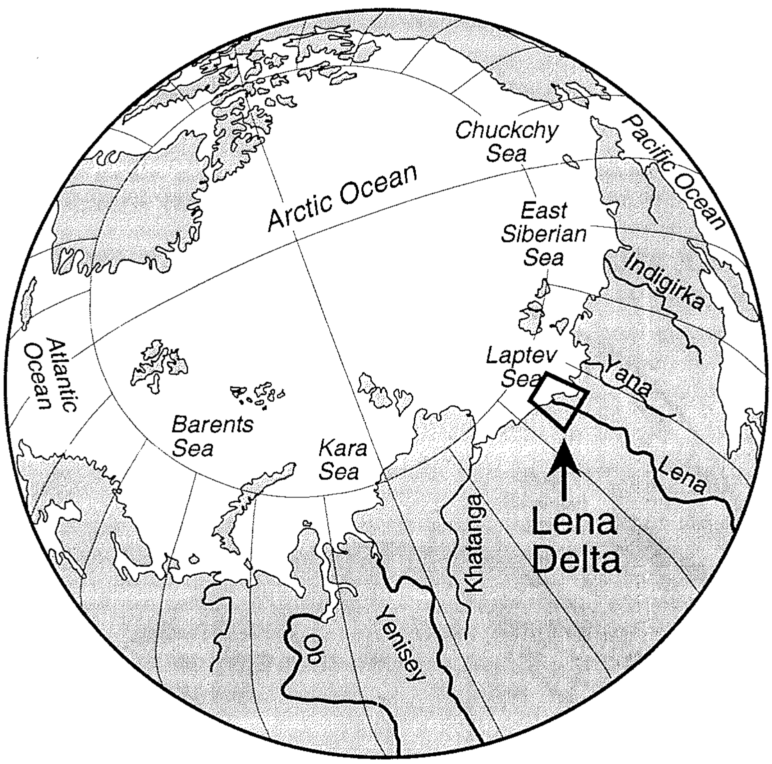

Figure 1-1: Map showing the location of the Lena Delta.

Acknowledgments

The success of the Lena Delta 98 expedition would have not 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 Hydrometeorological Service for logistic support in Tiksi, special thanks to D. Melnichenko. The members of the expedition wish to thank the captain of RV Dunay and his crew and the staff of the biological station Samoylov.

M. Antonow and V. Rachold greatly appreciate the support of R. M. Kamensky (Director of the Permafrost Institute, Yakutsk) during their visit in May 1998 when the foundations for a successful expedition were laid.

The expedition was funded by the German and Russian Ministries of Science and Technology (BMBF-Verbundvorhaben SYSTEM LAPTEV-SEE 2000, LAPEX).

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Kassens, H., Bauch, H., Dmitrenko, I., Eicken, H., Hubberten, H.-W., Melles, M., Thiede, J. and Timokhov, L. (in press), Land-Ocean systems in the Siberian Arctic: dynamics and history. Springer, Berlin.

2 Expedition Itinerary

(V. Rachold and M. N. Grigoryev)

2.1 Selection of working areas

With respect to the scientific program, the expedition group had been divided into four teams prior to the expedition. For each team specific working areas had been selected. The working areas of the four groups are shown in Figure 2-1.

Team 1 (Samoylov), which concentrated on modern processes of permafrost affected soils, used a biological station of the Lena Delta Reserve on the island Samoylov in the central part of the Lena Delta. The field work was carried out close to the station on Samoylov Island. Samoylov station is equipped with a kitchen, a dining room, some living rooms that were used as laboratories and a sauna. The participants lived in small tents during the expedition. A cook („Кошмар") was provided by the Lena Delta Reserve.

(→ *Chapter 3: Modern Processes in Permafrost Affected Soils).*

Team 2 (Dunay), which focused on modern and ancient sedimentation in the Lena Delta, was based aboard the vessel Dunay. During the expedition all major channels of the delta could be visited by the ship. In addition, Nikolay Lake on Arga Island was reached by helicopter. The vessel Dunay, which was chartered from the Tiksi Hydrometeorological Survey, is constructed for navigation work in the delta and in the coastal regions of the Laptev Sea. The participants of the expedition lived in one of the cabins of the ship. The ship is provided with a dining room, a cooker and a shower. Two motorboats for the work in shallow regions were available.

(→ *Chapter 4: Modern Sedimentation and Environmental History of the Lena Delta*)

For their paleoclimatic/paleoecological work program team 3 (Bykovsky) had chosen the locality Mammont Khayata on Bykovsky Peninsula. The 2 km wide and 40 m high ice-complex was studied and sampled in detail. The Bykovsky team lived in a field camp.

(→ *Chapter 5: Paleoclimate Signals of Ice-rich Permafrost*)

Team 4 (Sagastyr) carried out paleogeographical investigations along the Tumat Channel in the central part of the Delta and studied lake sediments on the island Sagastyr. The distance from the starting point at the Tumat Channel to the Polar station on the island Sagastyr was covered by rubber boats. For the way back to Samoylov Island motor boats of the Lena Delta Reserve were used.

(→ *Chapter 4: Modern Sedimentation and Environmental History of the Lena Delta*)

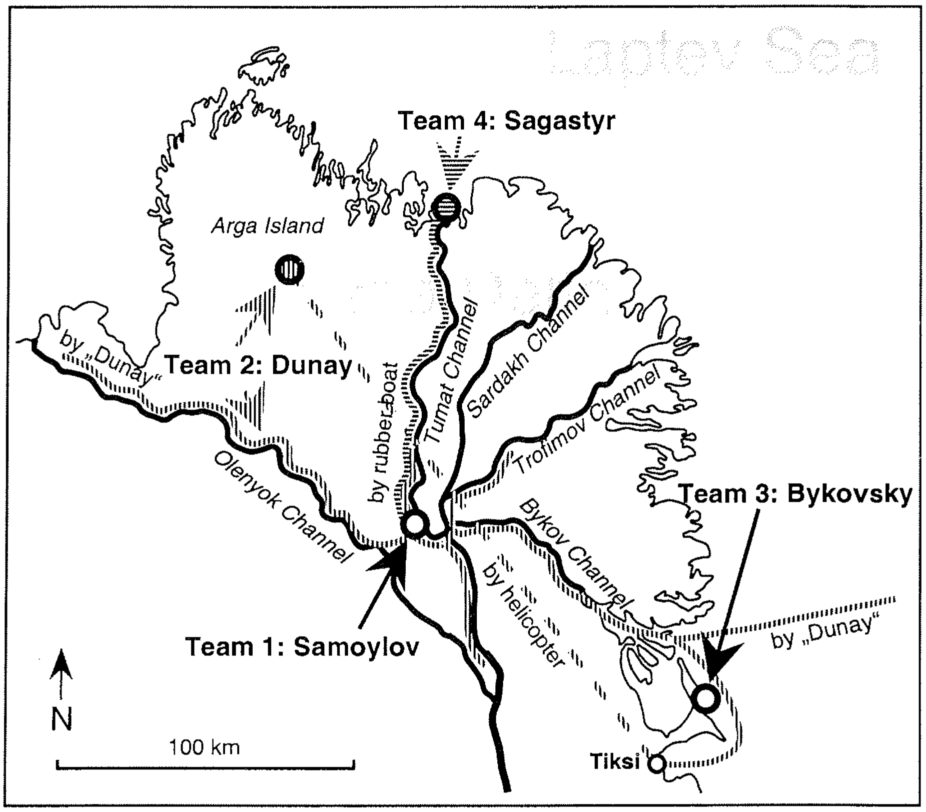

Figure 2-1: Location map of the Lena Delta 1998 expedition.

2.2 General logistics and transport

The general logistics of the Lena Delta 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.

Three weeks before the start of the expedition the German field equipment was sent to St. Petersburg by ship using a commercial cargo company. Except for fresh meat and fish all of the expedition food was bought in St. Petersburg. The German participants flew from Berlin/Hamburg to St. Petersburg on July 12.

After some days of preparation in St. Petersburg, the German and Russian participants and the entire equipment including two tons of food were transported from St. Petersburg to Tiksi by charter flight (IL 18) on July 15.

Due to the ice-conditions in the Tiksi Bay the transport of the four groups to their working areas could not be carried out by ship as originally planned. For that reason, helicopters (MI 8) were used to transport the first two teams to their working areas. On July 19 team 4 was brought to their starting point near at the

Tumat Channel and two days later on July 21 team 1 was transported to Samoylov Island.

Since in the same night strong southern winds opened the ice in the Tiksi Bay, team 2 could be transported to Bykovsky Peninsula by the vessel Dunay the next morning. After Dunay had returned to Tiksi the last group (Team 2: Dunay) could start with their work program on July 24.

During the expedition the vessel Dunay was not only used as a base for team 2 but also for logistic operations. On July 27 the transfer of the scientific crew of the German Polar Research Vessel Polarstern (ARK XIV1 b) which reached Tiksi by charter flight was carried out by Dunay. For that reason, Dunay picked up two members of the Samoylov group the day before and brought them to Tiksi. One of them had to fly back to Germany, the other one participated in the Polarstern cruise ARK XIV1b. Furthermore, two participants of the Lena Delta Expedition arrived at Tiksi together with the charter flight organized for the Polarstern crew.

At the end of the field work team 3 (Bykovsky) was transported back to Tiksi by helicopter on August 21. On the same day team 2 (Dunay) and team 4 (Sagastyr) arrived at Samoylov Island. On August 22 both teams together with team 1 (Samoylov) reached Tiksi onboard Dunay.

Having packed the equipment and samples in Tiksi all participants flew back to St. Petersburg by charter flight (AN 12) on August 25. The German participants returned to Berlin/Hamburg by regular flights on August 29.

During the expedition daily radio contact between the teams 1, 2, and 3 was maintained by three radio stations of „Angara" type, which had been supplied by the Tiksi Hydrometeorological Survey. For radio communication the times and frequencies of the Tiksi Hydrometeorological Survey were used. Radio contact to team 4 was provided by the Lena Delta Reserve.

Logistic operations in Tiksi (renting of busses, trucks, helicopters etc.) were organized by the Tiksi Hydrometeorological Survey.

2.3 Timetables of individual working groups

2.3.1 Team 1 (Samoylov)

July 21	Transfer Tiksi Samoylov with Helicopter, organization of the Camp
July 22	First overview surrounding the Island
July 23	Beginning of the digging and excavation of the main profile Plot No. 1, low centered-Polygon. Soil zoology: installation of pitfall-traps (capture of invertebrates living on the soil-surface), yellow traps (record of flying insects) and special emergence-traps at plot 3
July 24	Continuation of Draining and digging of Plot 1. Taking of microbiological soil samples. Soil zoology: installation of pitfall-traps, yellow traps and emergence-traps at plot 2 sampling (plot lb)) and extraction (for 10 days) of Enchytraeidae, conservation of samples soil samples are taken and conserved to study soil-living nematodes (plot 1b) and conservation of samples for later mechanical extraction of soil-inhabiting larvae

July 25	Start Installation of the main monitoring site (Plot No. 3). Establishing of Plot No. 2, drained sandy site. Soil zoology: control and emptying of traps. conservation of sampled material sampling (plot 2) and extraction (for 10 days) of Enchytraeidae, conservation of samples soil samples are taken and conserved to study soil-living nematodes sampling of plot 2 and conservation of samples for later mechanical extraction of soil-inhabiting larvae.
July 26	Leaving of Dr. Eva-Maria Pfeiffer and Dr. Dirk Wagner with the Dunay, Soil zoology: sampling of both plots and extraction of microarthropods (Acari, Collembola) from soil samples with Tullgren-extractor (for 3 days)
July 27	Start of the Soil-Temperature, and Moisture monitoring Daily measurements at 12 p.m.
July 28	Marking of 18 plots on the first Transect
July 29	Digging on the Transect and Soil description
July 30	Excursion to America Khaya by Motorboats
July 31	Installation of steel frames for methane measurement
August 01	survey of the surrounding of plot 3 for making a detailed map. Soil zoology: control and emptying of traps (plot Ib)), conservation of sampled material
August 02	arriving of the gas bottles on board of the Dunay, Installation of the Gaschromatograph Soil zoology: control and emptying of traps (plot 2), conservation of sampled material
August 03	Soil physical determination, determination of the gravimetrical soil water content
August 04	Arriving of the Agar-Group by Helicopter.
August 05	Gas sampling and soil monitoring
August 06	setting of the second Transect
August 07	Monitoring
August 08	Monitoring
August 09	Survey of Transect t
August 10	Survey of Transect w, Gas sampling control and emptying of emergence-traps
August 11	Survey of Transect v
August 12	Soil description on Transect v, excursion to Stolp,
August 13	Gas sampling and Soil Zoological Experiments: sampling of both plots and extraction of microarthropods (Acari, Collembola) from soil samples with Tullgren-extractor (for 3 days) sampling of both plots and conservation of samples for later mechanical extraction of soil-inhabiting larvae
August 14	Excursion to Kuringnak-Sise examination of one Pingo and Mud-boils, and soil-sampling.
August 15	Beginning sampling of undisturbed soil-samples for microbiological experiment at Plot 1, Gas Samples
August 16	Sampling of undisturbed soil samples for hydraulic conductivity
August 17	Taking of soil-monoliths for ecological experiments control and emptying of traps, conservation of sampled material
August 18	Excursion to Tit-ary
August 19	Taking of soil-monoliths for freezing experiments, taking of soil-cores for pore-size distribution
August 20	Removing of some of the Instruments, preparing the equipment for the hard and cold winter. Building up of sign post for marking the plots.
August 21	packing of the equipment and loading the Dunay. End of daily measurements.
August 22	Leaving Samoylov on Board the FS Dunay

2.3.1 Team 2 (Dunay)

July 24:	shipping from Tiksi to Samoylov Is.
July 25:	georadar studies on Samoylov Is. and hydrological work on the Lena River and the Olenyok Channel
July 26:	cruise from Samoylov Is. to Tiksi with stop in Bykovsky Peninsula
July 27:	transfer to RV Polarstern
July 28-29:	stay in Tiksi because of bad weather conditions
July 30:	helicopter flight to Nikolay Lake on Arga Island
July 31-August 3:	seismic studies of lake sediments of Nikolay Lake, geological sampling of one permafrost section, georadar studies, sampling of lake sediments
August 4:	helicopter flight to Samoylov Is.
August 5:	cruise from Samoylov Is. to the mouth region of Olenyok Channel
August 6-8:	hydrological work in the mouth region of Olenyok Channel, geological sampling of two permafrost sections along the Olenyok Channel
August 9:	georadar studies on Samoylov Is. and hydrological work in the Tumat Channel
August 10:	cruise from Samoylov Is. to Tiksi with stop at field camp on Bykovsky Peninsula
August 11-12:	hydrological work in the Laptev Sea NE off Bykovsky Peninsula and in the Bykov Channel
August 13:	hydrological work in the Trofimov Channel
August 14-15:	drilling Holocene terrace sediments of the Trofimov Channel
August 16:	Pleistocene sediments of Sardakh Channel
August 17:	hydrological work in the Trofimov Channel and cruise to Samoylov Is.
August 18:	hydrological work in the Lena River near Tit Ary
August 19-20:	drilling on Samoylov Island and hydrological work on the Lena River and in Bykov Channel
August 21:	packing of samples and equipment on Samoylov Is.
August 22:	shipping back to Tiksi

2.3.3 Team 3 (Bykovsky)

July 21-22:	transfer from Tiksi to Bykovsky Peninsula, landing at the camp position in the alass near ice complex (Yedoma) Mammont Khayata
July 23:	camp construction
July 24:	first overview: excursion to the region north of the camp (alass deposits and snow patches)
July 25:	second overview: excursion to the big outcrop region south of the camp (ice complex Mammont Khayata)
July 26-27:	marking and survey of the main outcrop positions, first ground ice sampling for stable isotope analysis (^{18}O, ^{2}H, ^{3}H), starting of laboratory work (pH, conductivity, anion/cation separation) installation of ground water and rain water bonds
July 28:	arrival of the Russian mammal paleontologist and excursion of the Russian geocryologist to Arga Island, selection of outcrops for detailed study on the thermoerosional coast of the ice complex Mammont Khayata
July 29:	beginning of the sedimentological, geocryological and paleontological investigations of baidzharakhs (thermokarst mounds) and sediment complexes in outcrop region of the ice complex Mammont Khayata, sampling and nivellement of paleosoils, investigations of the Mammoth Fauna and modern and paleoentomologic studies, studies of modern thermokarst processes
August 5:	working on sediments and ice wedges in the alass depression (outcrops at

	the Laptev Sea coast)
August 6-7:	studies of ice structure in ice wedges with polarization filters, hydrological studies of thermokarst lakes
August 8:	trip to Cape Mammoth, a thermoerosional outcrop at the Laptev Sea coast (the middle part of the Bykovsky Peninsula)
August 10:	end of the sedimentological and geocryological investigations in outcrop region of the ice complex Mammont Khayata
August 11:	visit of the Dunay-group, landing of the German OSL- geochronologist
August 12:	inspection for sampling of OSL-dating, sampling of ice wedges for cosmogenic nuclide ^{10}Be
August 13-15:	sampling for OSL-dating in the outcrop region of the ice complex of Mammont Khayata, sampling of surface waters (lakes, small streams, ice wedge bonds), drilling on the Mammont Bulgunniakh (pingo) in the alass near camp
August 16:	expedition to the coastal outcrops in the northern part of the Bykovsky Peninsula, 6.7 km south of Cape Bykovsky, sedimentological studies and sampling for OSL-dating, drilling of the region between pingo and camp
August 17:	camp-day because of the bad weather, working on samples in the laboratory tent
August 18:	last sampling for OSL-dating, sedimentological and geocryological studies in the southern part of the outcrop region over the snowfield, small overview excursion by boat along the outcrop coast, expedition to the Mammont Lake
August 19:	sedimentological studies on the outcrop Mammont Bysygasa in the northern part of the alass region, drilling of the region between camp and ice complex, last ground ice sampling for stable isotope analysis, end of laboratory work
August 20:	packing of samples and equipment, dismantling of the camp
August 21:	return to Tiksi by helicopter

2.3.4 Team 4 (Sagastyr)

July 18:	helicopter flight from Tiksi to Yugus-Yie (Yeppiries-Sise Is.)
July 19:	establishing pollen trap station in Yugus-Yie, collection of herbarium
July 20-21:	geological and geomorphological work in the vicinity of Yugus-Yie, sampling of one permafrost section along the Yeppiries-Tyubelege Channel
July 22-23:	sampling of one permafrost section and sampling of lake sediments of Yugus-Yie-Kyuele Lake on Yeppiries-Sise Is.
July 24:	packing of samples and equipment in Yugus-Yie for the cruise to Sagastyr Is.
July 25-26:	cruise from Yugus-Yie to Kyueiya-Kyuele Lake near Chenchiki-Yiete, geological and geomorphological studies of river banks, sampling of one riverside permafrost section along the small Tumat Channel
July 27:	geological and geomorphological investigations in the vicinity of Kyueiya-Kyuele Lake (Yeppiries-Sise Is.)
July 28:	cruise from Kyueiya-Kyuele Lake to Kukula-Kyuele Lake (Tyuert-Uon-Balyktakh Is.), sampling of one permafrost section along the small Tumat Channel
July 29:	stay near Kukula-Kyuele Lake because of bad weather conditions
July 30-August 2:	cruise from Kukula-Kyuele Lake to Ergulov-Kyuele Lake on Arga-Muora-Sise Is., geological and geomorphological investigations of river banks of the small Tumat Channel
August 3-4:	geological and geomorphological investigations in the vicinity of Ergulov-Kyuele Lake and Ogo-Olbyut-Kyuele Lake, sampling of lake sediments
August 4-6:	cruise from Ergulov-Kyuele Lake to Sagastyr Is., geological and geomorphological investigations
August 7:	stay on Sagastyr Is. because of bad weather conditions

August 8:	establishing pollen trap station on Sagastyr Is., collection of herbarium
August 9:	walk across Sagastyr Is. to the Laptev Sea coast and back
August 10:	stay in Sagastyr Is. because of bad weather conditions, packing of samples
August 11:	sampling of lake sediments of Kyuchuk-Kyuele Lake on Sagastyr Is.
August 12:	excursion to Skryabin-Apyta Is. by motorboat
August 13-14:	setting up memorable sign for the First Russian Polar Station which was founded on Sagastyr Is. in 1883 by Nicolay Yurgens
August 15:	sampling of permafrost section in the southern part of Sagastyr Is.
August 16:	packing of equipment
August 17:	cruise from Sagastyr Is. to Samoylov Is. by motorboats, reconnaissance geomorphological observations of river banks of the large Tumat Channel
August 18:	excursion to Tit-Ary Is.
August 19-20:	drilling on Samoylov Is.
August 21:	establishing pollen trap station on Samoylov Is., packing of equipment
August 22:	cruise back to Tiksi

2.4 Appendix

Table A2-1: *List of participants.*

Name	email	Institution	Team
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Table A2-2: Participating institutions.

AARI	Arctic and Antarctic Research Institute Bering St. 38 199397 St. Petersburg Russia
IBS-LN	International Biological Station „Lena-Nordensheld" 3/1 Dzerzhinsky St. 67700 Yakutsk Yakutia, Russia
KBI	Komarov Botanical Institute Russian Academy of Sciences Prof. Popov St. 2 197376 St. Petersburg Russia
LDR	Lena Delta Reserve 28 Academician Fyodorov St. Tiksi 678400 Yakutia, Russia
MGU-G	Moscow State University Faculty of Geology 119899 Moscow Russia
MGU-P	Moscow State University Faculty of Paleontology 119899 Moscow Russia
PIY	Permafrost Institute Russian Academy of Science 677018 Yakutsk Yakutia, Russia
SIEE	Severtsov Institute of Ecology and Evolution Russian Academy of Sciences 33 Leninskiy Prospect 117071 Moscow Russia
AWI-B	Alfred Wegener Institute PO Box 120161 D-27515 Bremerhaven Germany
AWI-P	Alfred Wegener Institute Research Unit Potsdam PO Box 60 0149 D-14401 Potsdam Germany
IPOE	Institute for Polar Ecology University of Kiel Wischhofstrasse 1-3 D-24148 Kiel Germany
IFB	Institute of Soil Science University of Hamburg Allende-Platz 2 D-20146 Hamburg Germany
SAS	Saxonian Academy of Sciences Research Unit Quaternary Geochronology Bernhard-von-Cotta-Str. 4 D-09596 Freiberg Germany
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3 Modern Processes in Permafrost Affected Soils

3.1 General introduction

(E.-M. Pfeiffer)

The big organic carbon pools of the Siberian permafrost soils play an important role for the reconstruction of former environmental changes and the prediction of future climatic influenced processes. Especially the carbon fixation in cryosols and the release of climate relevant trace gases like CO_2 and CH_4 due to the carbon decomposition are important for the global carbon budget. The multi-disciplinary soil studies are focused on the seasonal variability of the modern carbon fluxes in the permafrost region of the Lena Delta. The main scientific objectives are:

- the determination of the energy and water balance of the active layer
- the quantification of climatic, pedogenic and soil microbial parameters which control the production, oxidation and emission rates of trace gases in permafrost soils
- the balance of the carbon fluxes (CO_2 , CH_4) in different arctic tundra sites of the Lena Delta.

The soil investigation includes field measurements of the methane and carbon dioxide emissions of typical patterned ground-soil-vegetation-complexes and process studies of the methane fluxes (production, oxidation, emission). During the expedition 1998 the main processes of the summer period could be determinated.

3.2 Investigation site „Samoylov"

(I. Akhmadeeva, H. Becker, K. Friedrich, D. Wagner, E.-M. Pfeiffer, W. Quass, M. Zhurbenko, E. Zöllner)

Samoylov Island is one of the ca. 1500 islands of the Lena Delta. It is located in one of the main river channels (Olenyok Channel) in the southern part of the delta (N 72°, E 126°). The island is representative for the south-western part of the delta.

The area size of the island is about 1.200 ha and the age of the oldest areas with huge turf accumulation is estimated between 8.000 and 9.000 years (GRIGORYEV 1993). The highest point of the island has an altitude of 12 m a.s.l. and complies with the location of the oldest parts of Samoylov. The lowest parts are the shore sites with elevations about 4 m above sea level.

The island is divided in two areas with different geomorphologic patterns: an accumulation site in the western part and in an erosion site in the eastern part of the island. Recent erosion processes had formed an abrasion coast with a cliff of max. 8 m height and a narrow beach of about 1-3 m width. The frequently changes of the river water levels are leading to different periods of sedimentation and delivery of strongly stratificated soil and sediment layers, which are dominated by pure mineral substrates to organic rich materials and pure turf layers. The different erosion resistance of the sediment strata are responsible for the recent shoreline with overhangs and the thermokarst features of the former ice wedge polygons.

In contrast to the eastern area of the island, which is influenced by erosion, the western part is characterized by accumulation processes (fluvial and aeolian sedimentation). The texture of the accumulated sediments is dominated by the sand fraction. Typical are fine to medium sands; coarser sediments are missing.

A first map of Samoylov was produced by interpretation available air pictures and several field trips (Figure 3-1). The geomorphology of Samoylov is characterized by several terraces. It is possible to differentiate 4 terraces on the island:

- 1st terrace (low flood-plain) -accumulative - is formed by sandy river deposits which fall dry during low water levels and during drought periods. Vegetation is absent or very sparse. Greatest width of the terrace reaches on western and north-west coast, it is less on east and north-east. A southern coast practically is broken off in water.
- 2nd terrace (middle flood-plain) - accumulative - consists of sand, often muddied, with layers of peat and mud. Slope of terrace and excess above 1-st terrace are expressed very poorly. It is flooded with flood water almost annually. General covering by vegetation is from 20 up % to nearly 100 %. It is located in western part of the island and occupies about 20 % of its area.
- 3^{d} terrace (high flood-plain) is flooded with water only at high flood. It is hypothetically erosion escarp of fluvial terrace above flood-plain, because is composed by the same layered peatish-sand deposits of ancient delta flood-plain. This terrace meets fragmentarily on east coast of the island and on to western border of fluvial terrace above flood-plain. Here already is expressed polygonal microrelief. Polygons in basic have irregular form. Cracks are not deep, about 15-25 cm. The terrace is very wet. Water almost everywhere is on a surface, except for a part near terrace edge. Width of it is 50-130 m.
- 4th terrace is ancient fluvial terrace above flood-plain and occupies about 70 % of its area. The surface is broken by cracks on polygons, often wet or with little lakes in their centres. There are many large thermokarst lakes on the terrace surface.

The oldest parts of the island are dominated by polygon structures. The special hydrological situation with the restricted drainage of the shallow active layer, the low winter temperatures (yearly average -12 °C), the thin snow cover (< 10 mm precipitation per month in winter) and the sandy sediments lead to the critical thermal regime with the result of repeated frost cracking. This processes form the polygonal patterned grounds with ice-wedges.

The polygons differ in stage of development: active ice wedge with low and high centred polygons and thermokarst lakes occurs on the eastern part of Samoylov Island. The orientation of the axes of some lakes complies with the direction of the strong prevailing summer winds. Besides these themokarst lakes old river beds are responsible for the alignment of the lakes. Due to the soil water status all kinds of wet arctic tundra types grow on Samoylov: mossy tundra to sphagnum bog and wet fen to flooded sedges in the centre of the polygons.

Besides the fluviatile accumulation, the strong winds lead to the aeolian sedimentation of sands which covers wide parts of the eastern islands and lead to buried soil and plants complexes.

Ice rich permafrost is typical for the whole island. The permafrost table ranges between 30 cm and 70 cm below soil surface. The thickness of the active layer depends on the vegetation cover, the soil temperature, the water regime, the soil texture, the micro relief and the exposition of the site.

3.3 Soils of Samoylov Island

(H. Becker, I. Akhmadeeva, D. Wagner, E.-M. Pfeiffer, W. Quass)

3.3.1 Soil distribution and classification

Soil and vegetation mapping is carried out for the representative landscape units (terraces) and additional typical transects are described of the island (transects named T, V, and W; see Figure 3-1). Along the transects (Figure 3-1) 56 pits are described. The detailed soil descriptions are listed in the appendix (List A3-1). Most of the soils are Permafrost Peat-Gley. Beside the Russian classification, the soils are described by the eighth edition of the US Soil Taxonomy (Soil Survey Staff, 1998).

Stratified peatish-sand deposits of ancient delta flood-plain are the parent material for the pedogenesis of the Island Samoylov.

The Russian classification of the Samoylov soils is conform to the taxonomy presented by Jelovskaia, 1987:

Poorly Developed

Section: Poorly Developed (Primitive)

Order: Primitive Alluvial

Type: Permafrost Alluvial Layered Poorly **APr**

Developed (Primitive)

Section: Alluvial

Order: Alluvial Typical

Type: Permafrost Alluvial Turfness

Subtype: Permafrost Alluvial Turfness Typical **AT**

Type: Permafrost Alluvial Peat-Gley

Subtype: Permafrost Alluvial Muddy-Peatish-Gley **AMPshG**

Subtype: Permafrost Alluvial Muddy-Peat-Gley **AMPG**

Subtype: Permafrost Alluvial Muddy-Gley **AMG**

Section: Gley

Order: Humus-Gley

Type: Permafrost Turfness-Gley

Subtype: Permafrost Turfness-Gley Typical **TG**

Type: Permafrost Humus-Gley

Subtype: Permafrost Humus-Gley Typical **HG**

Type: Permafrost Peat-Gley

Subtype: Permafrost Peat-Gley **PG**

Subtype: Permafrost Peatish-Gley **PshG**

Section: Accumulative-Humus

Order: Accumulative-Humus Typical

Type: Permafrost Straw

Subtype: Permafrost Straw Grey **SG**

A detailed soil map of the Island is in preparation.

3.3.2 Soils of the measurement sites

The knowledge of the main soil and site parameters which influence the gas fluxes and the energy and water balance is necessary. The positions of the four measuring sites and their soil profiles were chosen after finishing the survey of Samoylov Island (Figure 3-1).

Site „low-centred polygon" (site 1 and site 3): The parent material of the well developed ice-wedge polygons are a poorly drained peats. Site 1 was used for the description of the patterned ground and soils. After digging a pit (size 2,8 m width and 1,1 m depth) with a special motor hammer, disturbed and undisturbed samples were taken for the chemical, biological and physical analyses. A comparable polygon (site 3) was described for the following gas measurements and energy / water balance investigations. To keep the perturbations by crossing as small as possible wooden path ways were built on site 3.

The Russian colleague classified the soils as Permafrost Peat-Gley. Using the American taxonomy the very wet soils of the low-centred polygons are Fluvaquentic Fibristels . These soil units are typical for Samoylov. A detailed description is given in Table 3-1.

Site „sand wedge polygon“ (site 2): This measuring site lies on the third terrace in a drained sandy area. A profile was dug from the centre to the border of a sand wedge polygon. For soil analysis the unperturbated centre was sampled. A detailed description see Table 3-2.

Site „initial tundra soil“ (Site 4): To compare the thermic and hydraulic data of a hydromorphic soil a fourth site was dug on the lower second terrace, which is vegetated by shrubs of willow. The finer textured soil had distinct hydromorphic features and typical gleyic horizons. A detailed description of Site 4 is given in Table 3-3.

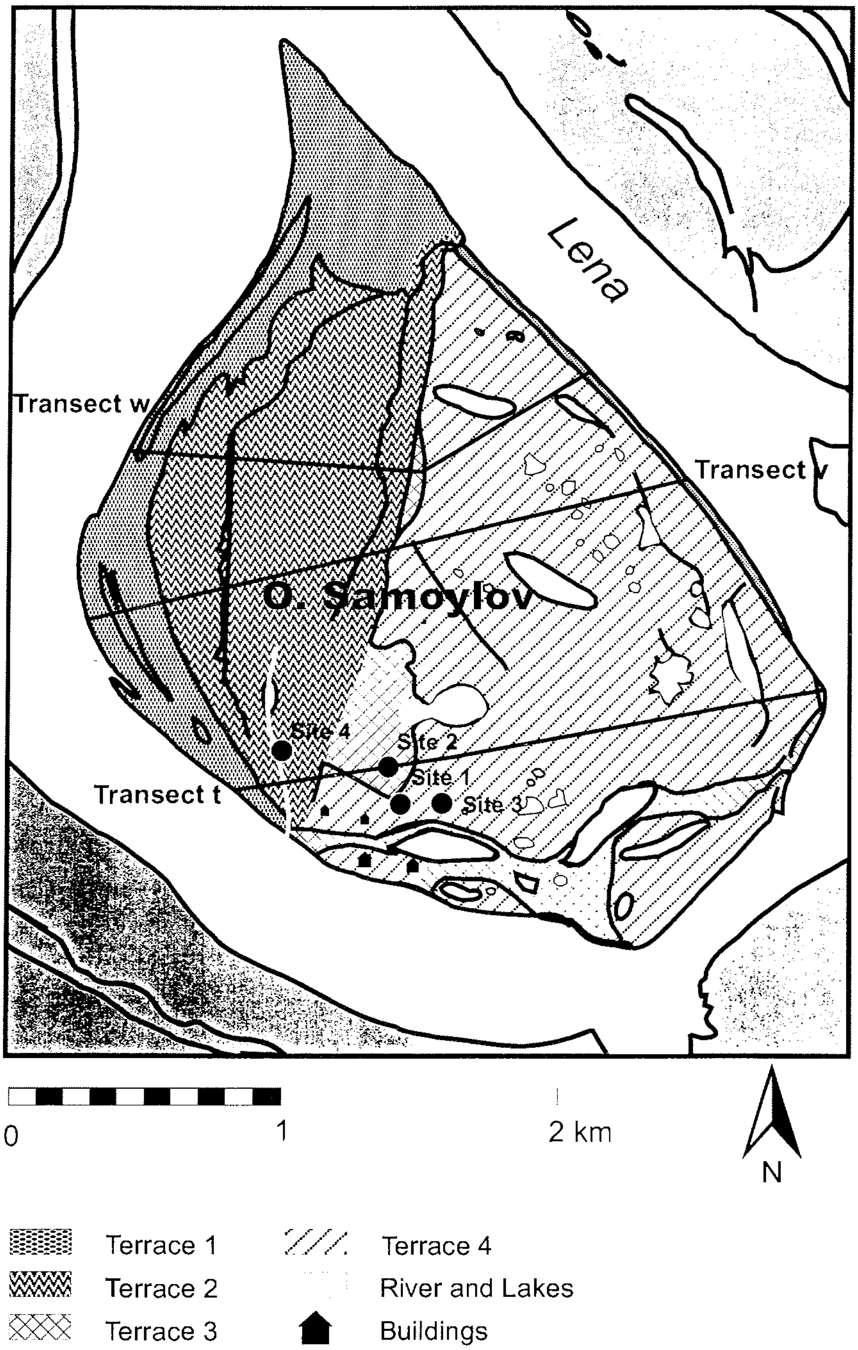

Figure 3-1: Map of the investigation area O. Samoylov

Table 3-1: Description of a *Fluvaquentic Fibristel* of a low-centred polygon; site 1

location:	O. Samoylov N 72° 22,22'; E 126° 28,54'
landform/ elevation:	flat elevation 12.7 m a.s.l.
climate:	average July temperature: 7 °C average year temperature: -12 °C average precipitation:190 mm per year
vegetation:	very wet arctic tundra with *Brophytes (80%), Carex concolor, Pyroloa spec., Dryas octopetala, Vaccinium uligonosum*
permafrost-table:	17-30 cm
parent material:	alluvial sands
hydrology:	very wet
Russian system:	Permafrost Peat-Gley

micro relief	depth [cm]	horizon	description
center	+14 - 0	Oi	organic material, slightly decomposed mossfibers and moss, greyish brown to dark brown (7.5YR4/2 7.5YR3/2),
	0 - 8	A	sand, very strong rooted, black (7.5YR2/0)
	8 - 13	Oi2	organic material slightly decomposed, extremely rooted positive α-α' dipyridil reaction, black (10YR2/1).
	13 - 17	Bg	sand, positive α-α' dipyridil reaction, strong rooted, very dark grey (7.5YR3/0).
	17 - 43	Oef	frozen organic material of Intermediate composition, very dark grey (10YR3/1).
apex	+5 - 0	Oi	organic material, slightly decomposed mossfibers and moss, brownish black (10YR3/1)
	0 - 8	A	sand, strong rooted, brownish black (10YR3/1).
	8 - 11	Oe	organic material of intermediate composition. Mineral fraction sand, brownish black (10YR2/2).
	11 - 19	Oe	frozen organic material of intermediate composition and sand layer, olive black (5Y3/1), dark reddish brown (5YR3/6) iron oxide spots, positive α-α' dipyridil reaction extremely rooted
	19 - 22	Bf1	frozen sand, grey (5Y4/1), strong rooted
	22 - 33	Bf2	organic rich frozen loamy sand, olive black (5Y3/1)very strong rooted
	33 - 49+	Bf3	frozen sand, grey (5Y4/1), very strong rooted

Table 3-2: *Typic Psammoturbel* of a sand wedge Polygon (site 2)

location:	O. Samoylov N 72° 22,24'; E 126° 28,53'
landform/ elevation:	third terrace 11 m a.s.l.
climate:	average July temperature: 7 °C average year temperature: -12 °C average precipitation:190 mm per year
vegetation:	*Dryas punktata, Arctagrostis arundinacea, Luzula tundricola, Pedicularis lanata, P. oederi, Hedysarumm arcticum, Bisorta elliptica, B. vivipara, Astragalus umbellatus, Bryophytes (90%), Cladonia pyxidata, Cetraria Islandica, Peltigra scabrosa, P. aphthosa*
permafrost-table:	52 cm
parent material:	alluvial sands
hydrology:	dry
Russian system:	Permafrost Alluvial Muddy-Peatish-Gley

centre

depth [cm]	horizon	description
+2 - 0	Oe	earth worms maybe genus *Eisenia*
0 - 4	A	very dark grey (7.5YR3/0) sand, strong rooted, high content of organic material
4 - 8	C	dark greyish brown (10YR4/2) sand medium rooted
8 - 13	Ab	very dark greyish brown (10YR3/2) sand, very weak rooted, medium content of organic material
13 - 19	C	very dark grey (10YR3/1) sand, weak rooted
19 - 25	Ab2	very dark grey (7.5YR3/0) sand, medium rooted, medium content of organic material
25 - 38	C2	dark yellowish brown (10YR4/4) sand , very weak rooted
38 - 60	Bb	black (7.5YR2/0) sand
60 - 68+	Bbf1	very dark brown (7.5YR2/4) sand

The area measurement of the centre and the border parts of the two polygon types (site 2 and site 3) is necessary for the calculation of the trace gas fluxes.

To compare the soil and patterned ground situation of Samoylov Island with other sites of the Lena Delta three daily excursions were done by boat. The other locations on Stolp Island, America-Caya Island and Kuringnak-Sise Island show that Samoylov is typical for wide parts of the southern delta.

The distinct soil-vegetation-complexes of Kuringnak-Sise are interesting for further investigations: This island had a higher elevation and was characterized by bigger ice-complexes, distinct thermokarst features and two pingos. The pingos were located in an old lake depression and seemed to be closed-system-pingos. The texture of the mineral soils was much finer (silty sands -

pure silt) than the sediments of Samoylov. The landscape was dominated by a dwarf shrub tundra with species like Betula spec., Salix spec.. Some interesting patterned-grounds like well developed polygons and mudpits were described and sampled in addition.

Table 3-3: Description of a *Psammentic Aquorthel*, Site 4

location:	O. Samoylov N 72° 22,32'; E 126° 28,07'
landform/ elevation:	second terrace 8 m a.s.l.
climate:	average July temperature: 7 °C average year temperature: -12 °C average precipitation:190 mm per year
vegetation:	*Salix glauca, S. reticula, Equisetum arvense,* Bryophytes (80 %)
permafrost-table:	52 cm
parent material:	alluvial sands
hydrology:	wet
Russian system:	Permafrost Alluvial Muddy-Peat-Gley

depth [cm]	horizon	description
+10 - 0	Oe	organic material of intermediate decomposition, very strong rooted,
0 - 10	A	sandy loam, very dark grey (2.5Y3/0), very strong rooted
10 - 20	A-Go	loamy sand, very dark greyish brown (2.5Y3/2), medium rooted, 5% iron-oxide spots
20 - 30	Bg1	sand, dark brown (10YR3/3) very weak rooted, 25 % iron-oxide spots colour (7.5YR5/8), positive α-α' dipyridil reaction
30 - 50	Bg2	sand, very dark grey (7.5YR3/0), positive α-α' dipyridil reaction

3.4 Energy and water balance of the active layer

(K. Friedrich and J. Boike)

3.4.1 Introduction

In arctic regions, the hydrology of the active layer plays an important role in understanding numerous physical, chemical, and biological processes. These include the seasonal thawing and refreezing of the soil, fluxes of carbon and methane and the transport of water and solutes. The moisture and heat transfer characteristics of the active layer also determine the boundary layer interactions of the underlying permafrost and the atmosphere and are therefore important parameters for geothermal or climate modeling.

The objectives of this study are:

- to study the energy balance and modes of energy transfer of the system active layer-atmosphere,

- to quantify the ties between energy balance and water and solute movement,
- to evaluate various methods (energy balance, water balance, microlysimetry) for the calculation of evapotranspiration.

3.4.2 Field work and methods

In July and August 1998, three soil profiles and a Campbell Scientific (CSI) automatic weather station (Table 3-4) were installed on the Samoylov Island in the Lena River Delta.

Table 3-4: Summary of instruments at the automatic weather station

Parameter	Instrument	Unit	Height of instrument	Measuring interval
Wind direction	Young Anemometer Model 05103-5	360°= North	2.85 m	10 s
Wind speed	Young Anemometer Model 05103-5	m/s	2.85 m	10 s
Air temperature I	MP 300	° C	2.0 m	20 s
Air temperature II	MP 300	° C	0.5 m	20 s
Relative humidity I	MP 300	%	2.0 m	20 s
Relative humidity II	MP 300	%	0.5 m	20 s
Netradiation	Q 7	W/m^2	1.3 m	10 s
Precipitation (rain)	Tipping bucket rain gauge	mm	ground surface	10 s
Snow depth	Sonic ranging sensor SR 50	m	1.695 m	1 d

The soil sites were chosen with respect to slope aspect, vegetation, thaw depth of the active layer and terrace of the island (Figure 3-1). Sites 2 and 4 were installed using triple wire Time Domain Reflectometry (TDR) probes, PT100 temperature probes, wells and suction lysimeters and were recorded manually throughout the summer. Site 3a/b is located close to the automatic weather station on the 4th terrace of the island on a low centered polygon. Instruments were inserted across the ridge of a low centered polygon (Figure 3-2; Automatic soil station at the site 3a/b) and automated using a CSI CR10X datalogger. A summary of methods, instruments and installation depths for all sites is presented in Table 3-5 and 3-6. Ground water samples were collected from wells using PVC tubing and plastic syringes and from the vadose zone using suction lysimeters. Electrical conductivity and pH of ground and soil water was measured every other day. Precipitation was sampled after each event. Water samples from suction lysimeters were taken for stable isotope, anion and cation analysis in Germany (Appendix, Table A3-1).

Table 3-5: Summary of methods and instruments used for the soil sites

Parameter	Instrument	Unit	Method
Soil moisture	Tektronix 1502C	travel time (ns)	TDR
Soil bulk electrical conductivity	Tektronix 1502C	reflection coefficient (mrho)	TDR
Microlysimetry	Tektronix 1502C	travel time (ns)	TDR
Snow moisture	Tektronix 1502C	travel time (ns)	TDR
Soil temperature	CSI 107 temperature probes	resistance (ohm)	Steinhart Hart equation
	PT100 temperature probes	resistance (ohm)	
Heat flux	Heat flux plates	voltage (volt)	
Groundwater depth	Well	depth (cm)	water level tape
Thaw depth	'Permafrost' probe	depth (cm)	probing

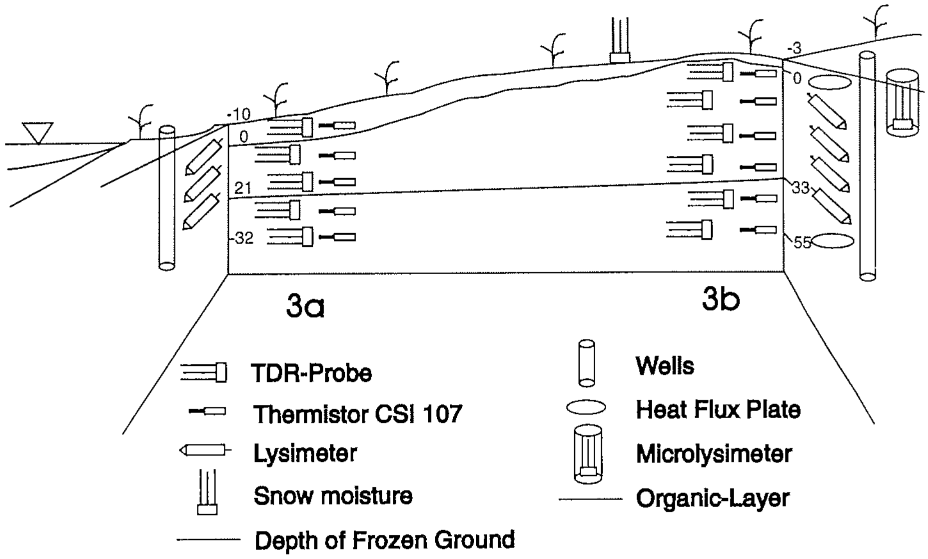

Figure 3-2: Automatic soil station at the site 3a/b

Table 3-6: Depth (cm) of installed instruments at sites 2, 3 and 4 in mineral soil. Negative depths refer to the organic layer above the mineral soil.

	Nr.	Site 2	Site 3a	Site 3b	Site 4
TDR/temperature probes	1	5	-3	6	-4
	2	21	3	12	4
	3	43	13	25	14
	4	65	22	34	23
	5	83	32	44	35
	6	96		55	50
Heat flux plates	1			5	
	2			52	
Suction lysimeters	1	55		14	37
	2	38		27	27
	3	15		36	17
	4		9		8
	5		15		
Wells	1	69	27	37	50

3.4.3 First data

Weather data collected at the automatic weather station from 24 July to 21 August are depicted in Figure 3-3. Over this period, a total of 32 mm precipitation fell in form of rain. Of note is the importance of wind for the local climate: northwest/north/northeast winds originating from the Laptev sea about 150 km north were cold and humid compared to warm and dry winds from the continental south.

The depth of thaw of the active layer at the end of the field season varied between a maximum of 80 cm at site 2 and 32 and 45 cm at site 3a and b.

3.4.4 Future work 1999

It is planned to continue the measurements for at least two more freeze-thaw cycles of the active layer, i.e. until at least 2000.

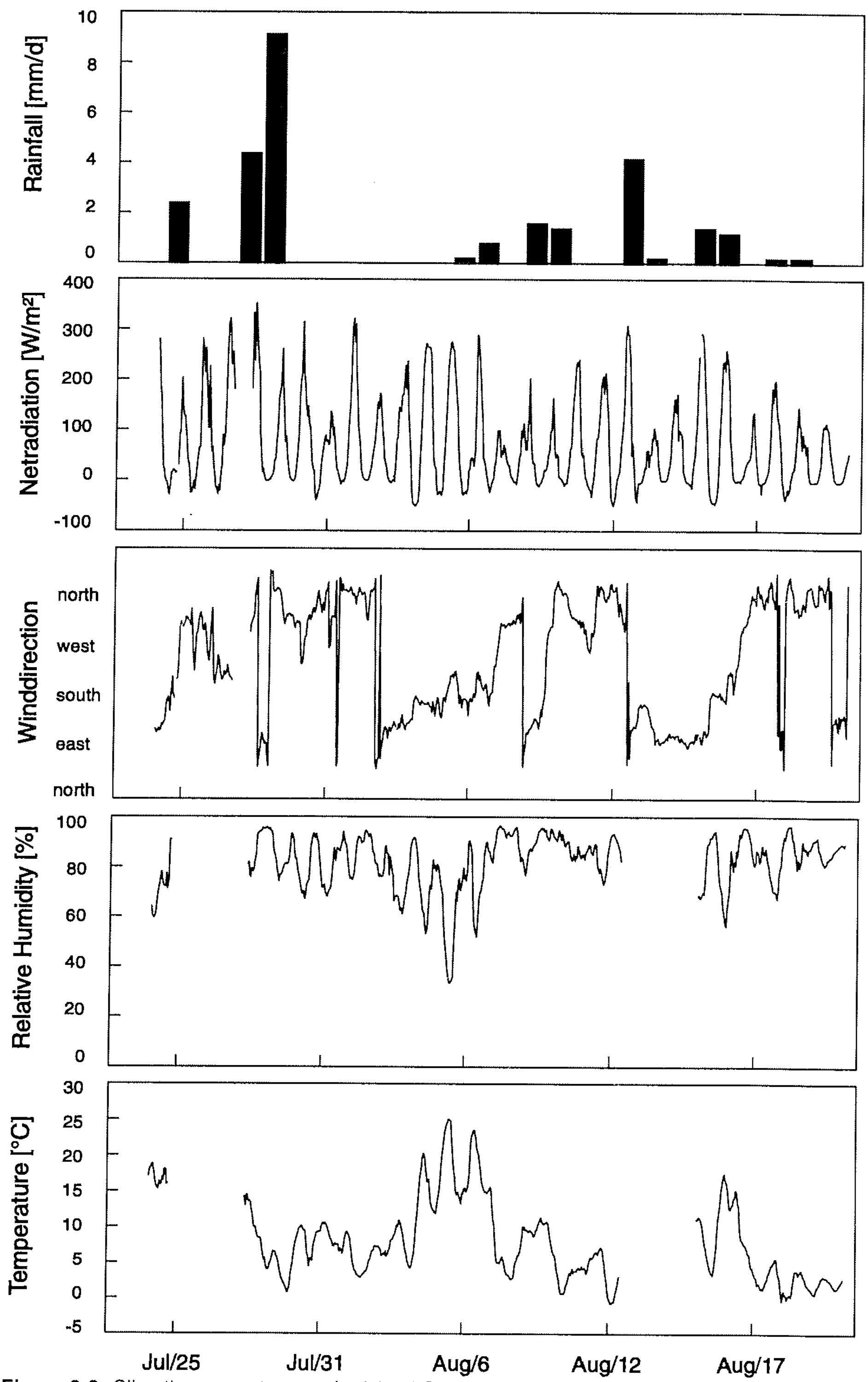

Figure 3-3: Climatic parameters on the island Samoylov

3.5 Trace gas fluxes in permafrost affected soils

3.5.1 Methane balance

(H. Becker, D. Wagner and E.-M. Pfeiffer)

3.5.1.1 Introduction

Terrestrial environments cover less than 30 % of the earth's surface but play a major role in the composition and dynamics of atmospheric trace gases. For example, about 50 % of the total global CO_2-production occur in terrestrial ecosystems (SCHLESINGER 1991). The expected percentage of atmospheric methane originates from terrestrial ecosystems is quite higher (CICERONE and OERMLAND 1988, CRUTZEN 1991). The importance of methane as a greenhouse gas originates from natural and anthropogenic sources is well known (ASELMANN and CRUTZEN 1989, BOUWMANN 1989, IPCC 1994).

Natural wetlands (marsh, bog, tundra) are the most important source of atmospheric methane (VOURLITIS and OECHEL 1997). The biggest group (26 %) of natural wetlands is wet tundra located above 60° N (MATTHEWS AND FUNG 1987). An immense part of this wetlands (1500 x 10^9 m^2) is on the territory of the former Soviet Union (HARRIS et al. 1993). Only sparse data about the methane cycle in this regions are already existing (VERCHERSKAYA et al 1993,SAMARKIN et al. 1994, NAKAYAMA 1995, INOUE et al 1995, HEYER and BERGER 1995, GUNDELWEIN 1998).

About 14 % of the global soil carbon are stored in arctic and subarctic regions (BILLINGS 1987). Therefore the most important question for the recent climate development is the role of this huge soil carbon storage. How will the carbon pool react under a changing climate?

The scope of this part of the project is the quantification of the main processes of the methane cycle in the permafrost affected soils. We describe the soils of the investigation area and study the main soil properties (i.e. thickness of the active layer, carbon content, porosity) in relation to the trace gas release. Two main processes are in focus of our investigations: the process of methane formation and methane consumption. These two parts of the methane cycle are of microbiological origin. Our aim is the inquire of the main processes and parameters which are regulating the methane formation and consumption.

3.5.1.2 Methods and fieldwork

Methane emission: For the measurement of methane emission we use the static chamber method. The chambers were build out of clear PVC. The dimensions of the chambers were 50 * 50 * 5 cm (12.5 l). Stainless steel frames with a u-shape profile at the top were inserted into the soil. During measurements the profile was filled with water to serve as a seal when the PVC chambers were on the top of the steel frame. Air was pumped through the chambers and a connected gas collecting tube with a small membrane pump connected with rubber tubing's (Tygon tubings, Figure 3-4).

Emissions were measured by sealing the chamber on the steel frame and removing 150 µl aliquots of the headspace gas after 30 minutes closing time with a gas tight syringe.

The methane concentration was measured with a gas chromatograph equipped with flame ionisation detector (Chrompack GC 9003).

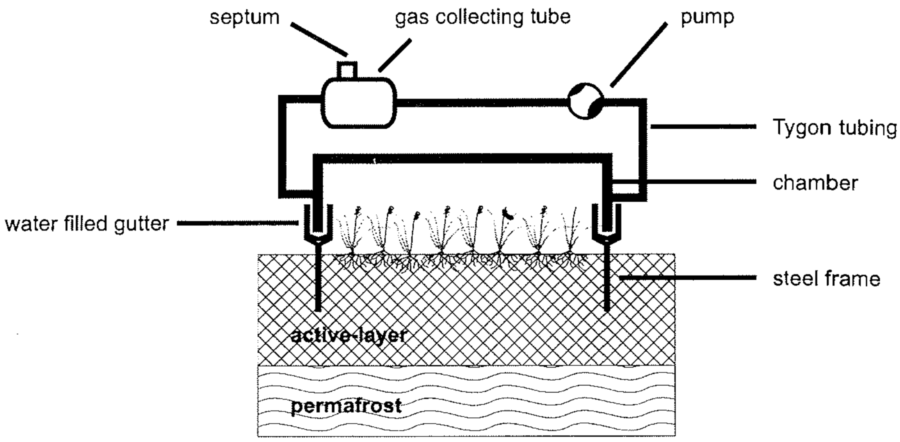

Figure 3-4: Schematic illustration of the methane emission measurement by static chamber technique

Methane oxidation: A new method for methane oxidation measurement in the field was tested. The same equipment as for methane emission measurement was used. They were installed on dry and sandy places (site 2 and site 4) where the methane oxidation would probably be high. After closing the chambers methane was injected, and immediately after mixing the air inside the chamber, we took gas samples (t0) to determine the methane concentration. After 30 min incubation a second sample was taken (t1). The oxidation capacity was calculated from the difference in methane content between t0 and t1.

Methane formation: Soil samples in gas tight plastic jars (Nalgene) were collected to determine the potential methane production rates in the laboratory. For the detailed method see WAGNER 1998.

Soil sampling and survey: Several types of soil samples were taken. For physical soil parameters like porosity and water conductivity undisturbed samples (100 ml steel cylinders) were taken. Samples for microbiological investigation were taken in gas tight jars (Nalgene) and transferred to the laboratory under cold conditions (≤ 4 °C). Soil samples for chemical analyses were dried and packed in plastic jars.

The elevation of Samoylov was measured by using a theodolite (THEO 2T5K, N36352).

Plant sampling: The dominant plant species of the measurement sites were collected and air dried for the chemical and isotopic analysis. Plants of site 1a: Carex concolor, Comarum palustre, Warnstorfia exannulata, Limprichtia cossoni. Plants of site 1b: Dryas punctata, Salix glauca, Hylocomium splendens, Aulacomnium turgidum. Plants of site 2: Dryas punctata, Hedysarum arcticum, Entodon concinnus, Aulacomnium palustre, Dactylina arctica.

3.5.1.3 Results of the soil survey and geological investigations

The results of the soil survey and geological investigations were presented above (see Chapter 3.2 and 3.3), whereas the soil microbiological, chemical and physical analyses are still in progress.

3.5.1.4 First results of the methane gas fluxes

The results of the methane measurements at site 3 show very clearly the differences in the micro relief of the low-centred polygon (Figure 3-5). At every sampling time, the emission of methane from the higher and dryer polygon wall was lower than the emission from the wet polygon-centre. An interesting result showed the observation at 5th of August: The analyses of the methane balance showed a methane uptake for the polygon wall and a low emission rate for the polygon centre. The measured amount of emitted methane from site 3 is within the range for wet tundra found in the literature (WHALEN and REEBURG 1992, VOURLITIS and OECHEL 1997, GUNDELWEIN 1998).

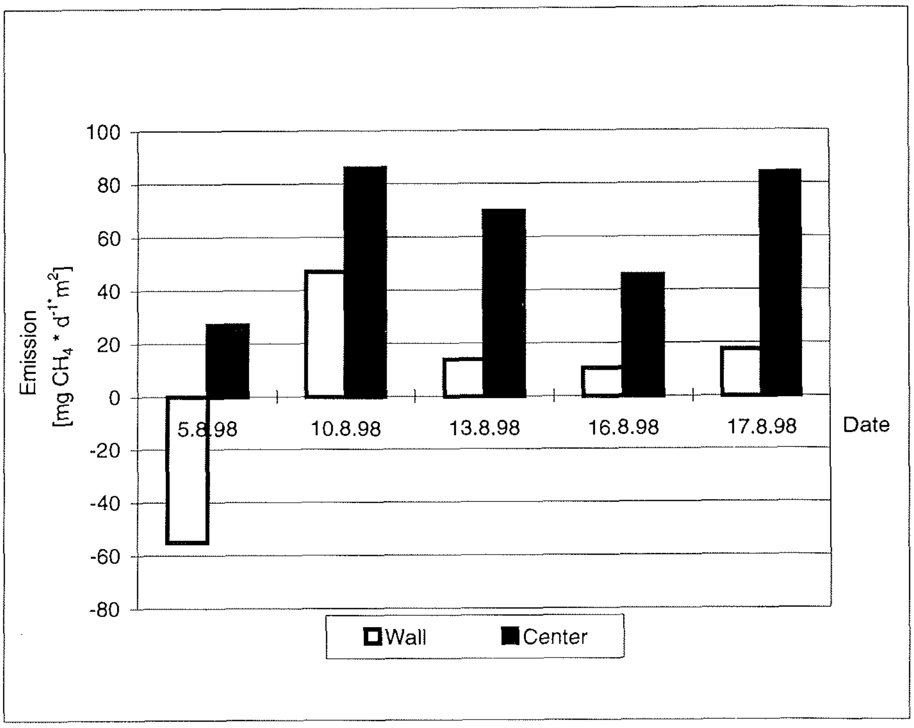

Figure 3-5: Methane balance of a low-centred polygon

3.5.2 CO_2- fluxes in permafrost affected soils

(W. Quass)

3.5.2.1 Introduction

Soil respiration is the in-situ CO_2-flux from the soil to the atmosphere which originates from the root and the microbial respiration. Several environmental and phytological factors are controlling the emission of CO_2 from the soil to the atmosphere. The pure diffusion process is modified by meteorological, hydrological and soil physical parameters.

Wet and cold conditions in arctic soils lead to a restricted decomposition under unfavourable conditions and therefore to the development of huge carbon stocks (GORHAM 1991). 90 % to 98 % of the total carbon of the tundra ecosystem is located in the soil (MILLER et al. 1983).

The objectives of this study are in the first place the determination of the soil respiration in the different soil horizons. The dominant CO_2-evolution can be attributed to the soil layers where high amounts of organic matter are available, oxygen can penetrate through the soil pores and an elevated temperature above 0 °C can be anticipated for an appropriate to maintain metabolic processes.

Hence, measurements on such environmental parameters are necessary to relate the CO_2-evolution to environmental properties. It is in our hypothesis, that changing environmental conditions have significant effects on the CO_2-exchange of the soils and that our measurements on such factors will help to elucidate model parameters for the recent and former gas fluxes in this environment.

Following laboratory work should give more information about the detailed temperature dependence of the microbial capability.

3.5.2.2 Methods and fieldwork

For determination of the environmental conditions of the microbiological habitats, the temperature and the soil water content are two of the main influencing abiotic factors. The microclimatic measurements of soil temperature were carried out by use of Thermistorperlen (FF-U) and datalogger (Grant, UK) at site 2 and 3. The temperature was measured daily at fixed times and also continuously. The depth of the active layer was determined, as well as the changes of the soil water content with the help of TDR (Soil Moisture Meter, Easy Test). The soil water content was, for a correction of the TDR data, analysed gravimetric in intervals with the help of a moisture analyser (Sartorius, Germany).

For the laboratory work (grain size analysis, pore size distribution, hydraulic conductivity saturated and unsaturated) undisturbed soil cores were taken (5 parallels). Core sizes are 100 cm^3 and 236 cm^3. For freeze and thaw cycles investigations, in connection with the gas flux and the stability of the soil pores, convertible soil cores, 16 x 8 cm, were taken.

To recieve more information about the influence of the soil water content and the temperature dependency and furthermore to allow comparisons of microbial habitats between the different sites (site 1 and 2) samples in different sizes were taken for laboratory gas exchange experiments.

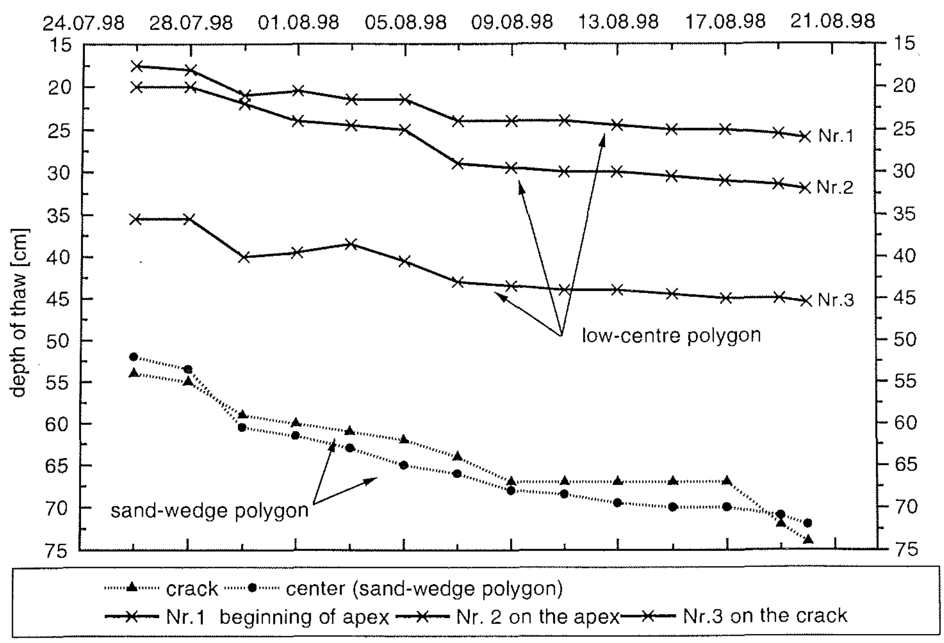

Figure 3-6: Thaw depth of a *Fluvaquentic Fibristel* and *Typic Psammoturbel* (Site 2 and 3)

3.5.2.3 Results

Basal rates of CO_2-effluxes are a function of the amount and quality of live and dead organic matter. The dominant controls in moist tundra appear to be depth of thaw and soil water table (OBERBAUER et al. 1996). The thaw depth determines the respiratory volume of soil while a saturated soil hinder oxygen diffusion and limits the respiration rates. Soil temperature has strong effect on the respiration of aerated soils. Figure 3-6 shows the depth of thaw of site 1 and 2. At the low-centred polygon the depth of thaw was determined at a transect through the apex. At site 2, the sand-wedge polygon, was measured in the crack and in the centre.

The increase of the active layer depths in the polygonal tundra is not homogenous between the apex of the low-centre polygon and the sand-wedge polygon. The missing isolating vegetation cover and the drier soil condition at the sand-wedge result in higher thaw depths. The insulating effect of the good developed moss-layer at the low apex microsites led to a high frost table.

Table 3-7 represents data from current investigations of CO_2-efflux in arctic environments. The measured values on Samoylov island comply with the data found in the literature.

The temperature curve in Figure 3-7 gives information about the temperature distribution in different soil depths of the Typic Psammoturbel (site 2; sand-wedge polygon) over a period of five days. The curves show diminishing amplitudes with increasing soil depth. High fluctuations at the soil surface are not reaching soil depths further than 40 cm.

Table 3-7: Data from current investigations of CO_2-efflux in arctic environments

Investigator	study area	CO_2-efflux [g $m^{-2}*d^{-1}$]
Oberbauer, S.F. – 1996	Brooks Range, Alaska (1990) moist Cassiope dwarf-shrub heath tundra Pergelic cryochrepts	4,9 - 5,8
Christensen, T.R. - 1997	Abisko (sub-arctic), Sweden tree line heath site	2,8 - 5,04
Poole, D.K. - 1982	north-central Alaska	
	tussock tundra	2,3
	shrub tundra	1,4
	lichen-heath	1,7
Oberbauer, S.F. – 1992	Brooks Range, Alaska (1990)	1,0 - 10,0
	riparian tundra	1,2 - 1,6
Sommerkorn, M. - 1998	Taimyr Penninsula	
	Polygonal tundra wet sedge tundra tussok tundra	1,1 - 1,6
Becker, H. Quass, W.; Wagner D. Pfeiffer E.-M.- 1998	Lena-Delta, Siberia	
	Typic Psammoturbel (sand-wedge Polygon)	2,3 - 5,8
	Fluvaquentic fibristel (low-center Polygon)	4,5 - 7,9

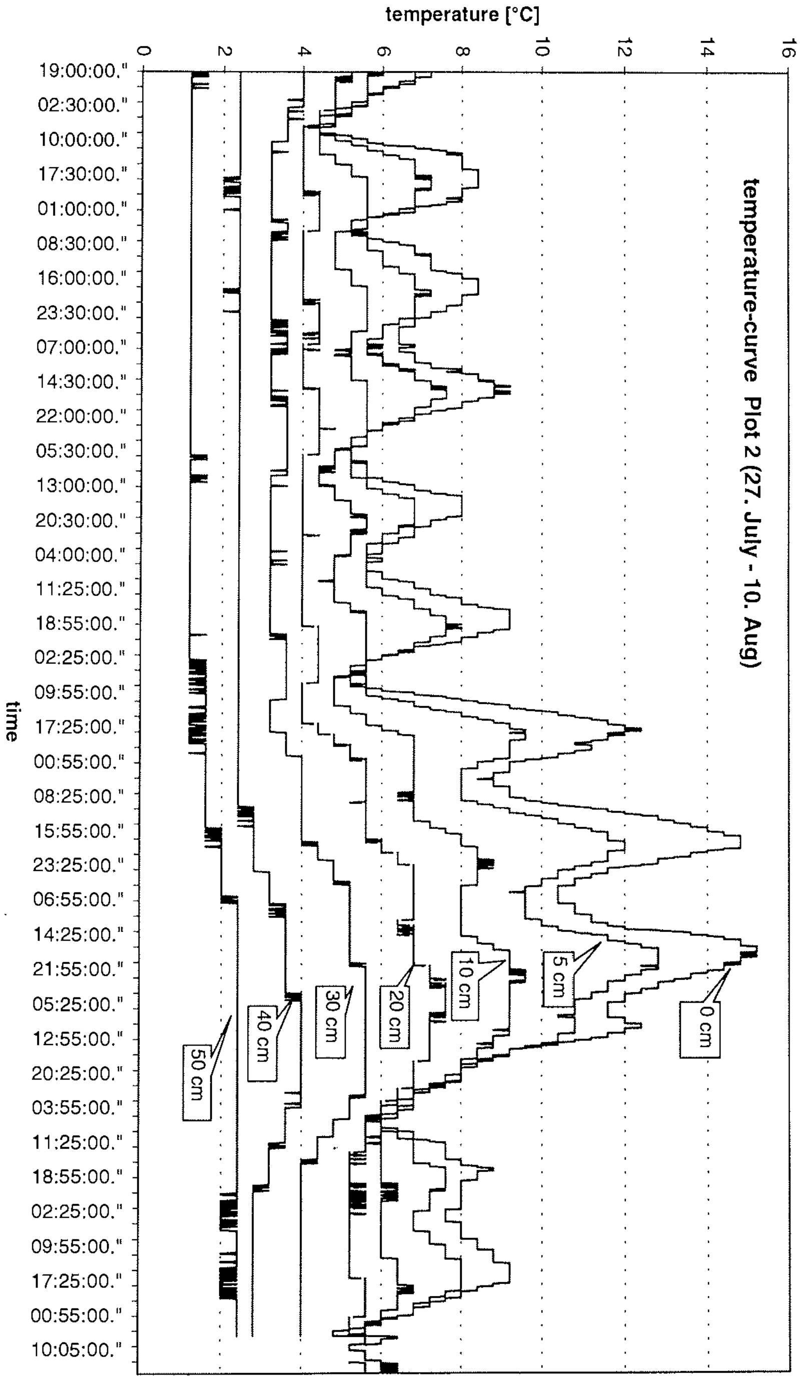

Figure 3-7: Time dependent temperatures in various soil depth.

3.6 Biological investigations

3.6.1 Botanical research

(M. Zhurbenko, I. Akhmadeeva)

For all measurement sites and soil transects the distribution of vascular plants, lichens and bryophytes were determined. On Samoylov Island 280 plants were found: 173 taxa vascular plants, 54 taxa bryophytes and 53 taxa lichens. The vascular plants were determined by Ju. P. Kozhevnikov after nomenclature by CZEREPANOV 1995. The bryrophytes were determined by I. V. Czernyadjeva after nomenclature by AFONINA and CZERNYADJEVA 1995. Both collegues are from the Komarov Botanical Institute (KBI). The preliminary list of the plant species is given in the appendix (List A3-2).

The first results of the main sites are:

Site „*low centre polygon*" (site 3, *Fluvaquentic Fibristel*):

Very wet centre:

22 % total vegetation above water: 20 % *Carex concolor*, 2 % Bryophytes
80 % total vegetation under water: 40 % *Carex concolor*, 40 % Bryophytes

Moderate wet border:

100 % total coverage: 64 % vascular plants with the dominant species *Carex concolor* 15 %, *Salix glauca* 10 %, *Dryas octopetala / Arctous erithrocarpa* 10 %; 90 % Bryophytes; 10 % Lichens.

Site „Sand wedge polygon" (site 2: *Typic Psammoturbel*)

At this dry and sandy site there was no distinct difference of species composition for the micro relief of the polygon. There was a higher coverage of bryophytes and higher diversity of lichens in the border position of the polygon:

100 % total coverage: 40 % vascular plants with the dominant species *Dryas puncta* 15 %, *Arctous alpina* 15 %, *Hedysarum arcticum* 5 %, *Luzula ssp.* 5 %; 70 % Bryophytes, 20 % Lichens with *Peltigera aphthosa* as dominant species.

The complete interpretation of the main patterned ground-soil-plants-complexes is in progress.

3.6.2 Soil zoological research

(E. Zöllner)

3.6.2.1 Introduction

Soil arthropods, in arctic regions predominantly mesofauna-organisms (0,2-2 mm) like Collembola and Acarina, directly and indirectly affect the CO_2-gasfluxes and carbon-cycle in soils for various reasons.

Detritivorous and microphytophagous microarthropods are involved in the process of decomposition and accelerate mineralization. They are important for the immobilization, concentration and distribution of nutrients and influence the soil structure because of bioturbation processes. Furthermore, they have an effect on abundances (grazing) and distribution of soil-living bacteria and fungi and contribute to the heterotrophic respiration in the soil.

Only the western part of the Northern palaearctic, including Svalbard and Taymyr Peninsula, has been sufficiently explored regarding soil fauna. This however only refers to Collembola which is one of the most numerous microarthropod groups in the Arctic soils (BABENKO, 1995).

As for other soil invertebrates, more or less considerable data can only be obtained on oribatid mites (KARPPINEN and KRIVOLUTSKY, 1982), but these are mostly based on the collections from more southern (hypoarctic) regions (BABENKO, 1995).

Thus there seems to be a necessity for further soil zoological research in the eastern part of the northern palaearctic. Therefore the dominant microarthopod groups of Acari and Collembola are in the scope of the soil zoological investigations on Samoylov island.

The regional mesofauna in conjunction with the habitat/microhabitat peculiarities of the study sites 2 and 3 was examined. These biotic features of the main sites were analysed in addition to the microbiological research and in connection to the abiotic soil parameters.

3.6.2.2 Field work

Microarthropod sampling took place twice during the stay on Samoylov Island (26.07. and 13.08.1998). Their extraction from soil cores (5.5 cm diameter, 8 to 12 cm depth, 4 replicates) was carried out immediately after sampling with a Tullgren-extractor (25W-lamps), which was placed in a wooden shed. The extraction time was 60 hours, using distinct heating intervals (15, 20, 25, 30, 40 °C).

Surface-dwelling Collembola and other surface-living invertebrates were also collected using pitfall-traps. Another aim of the research is to get abundance data and biomass estimates on other soil-invertebrates like Enchytraeidae and Nematoda, which have scarcely been investigated in northern Yakutia (personally from N. POTAPOVA, Yakutia).

Soil cores were taken and extracted for Enchytraeidae as well as small soil samples, which were preserved in formalin (4 %) for later direct counting. In order to determine how important the presence of diptera in the soil is at the two main sites, samples for mechanical extraction of larvae were taken. Furthermore, emergence-traps (1/4 m^2) were installed to quantify adult diptera which emerge from the soil (see Figure 3-8).

For assessment of biological activity of the soils at the two main sites (the feeding activity of the soil mesofauna respectively) a bait-lamina-test (TÖRNE v.,

1990) was carried out.

To get additional information concerning the soil mesofauna and to trap soil microarthropods, minicontainer (EISENBEIS, 1995) were used.

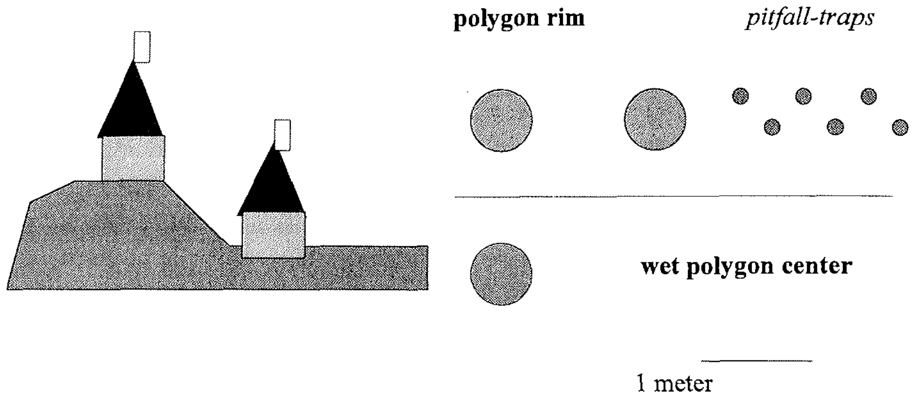

Figure 3-8: Site 3; position of emergence-traps (left, transverse section) on polygon rim and in the marginal region of wet polygon centre; position of emergence-traps and pit-fall-traps seen from above.

3.6.2.3 First results

The complete taxonomical and ecological analysis of the collected soil fauna is a very time-consuming task. Therefore, only a few data and impressions, based on a first sorting of samples, can be presented here. Most animals are concentrated on the few uppermost centimeters of the soil profile, the zone of living and dead plant material. For this layer abundance data of Acarina vary between 10,000 and 26,000 individuals • m^{-2} (site 2) and 22,000 up to 35,000 individuals • m^{-2} (site 3). In deeper soil layers only 1000 - 20,2000 individuals • m^{-2} can be found. Abundance data for Collembola are less variable and differ between 28,000 and 32,000 ind • m^{-2} at site 2 and between 25,000 and 32,000 ind • m^{-2} at site 3.

Figure 3-9 shows first abundance data (individuals • m^{-2}) of the two dominant microarthropod groups Collembola and Acarina sampled at site 2. Figure 3-10 show this data for site 3 .

Within each plot the abundance data is presented for two microhabitats formed by different vegetation covers, *Dryas punctata* (site 2), *Carex sp.* (site 3) and mosses (dominant at site 2 and 3).

Most animals are concentrated on the few uppermost centimeters of the soil profile, the zone of living and dead plant material. For this layer abundance data of Acarina vary between 10,000 and 26,000 individuals • m^{-2} (site 2) and 22,000 up to 35,000 individuals • m^{-2} (site 3). In deeper soil layers only 1000 - 20,2000 individuals • m^{-2} can be found. Abundance data for Collembola are less variable and differ between 28,000 and 32,000 ind • m^{-2} at site 2 and between 25,000 and 32,000 ind • m^{-2} at site 3.

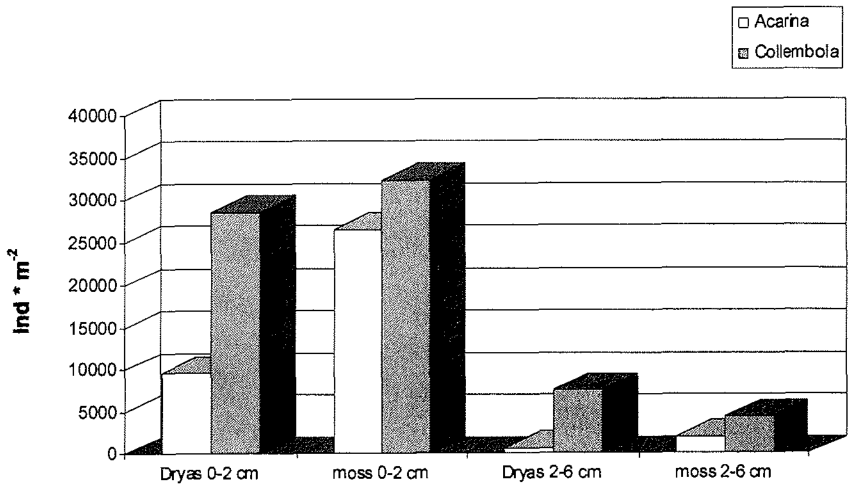

Figure 3-9: Abundances of microarthropods at site 2

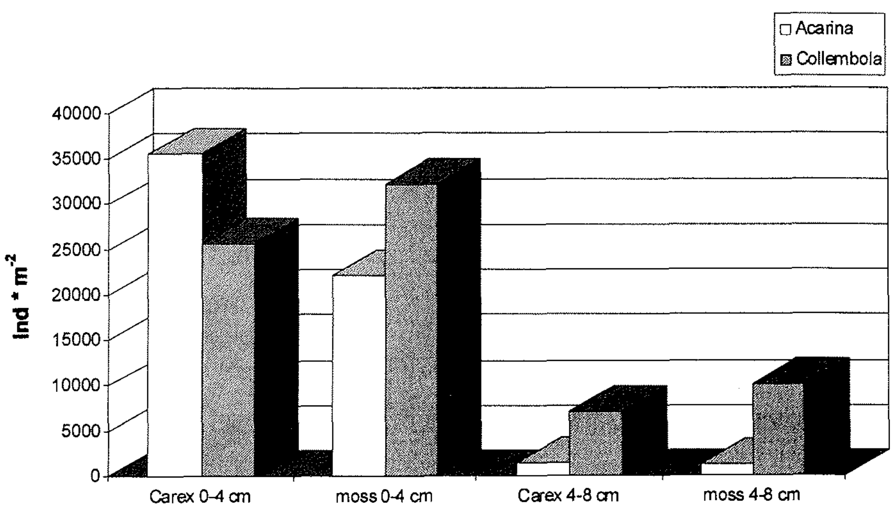

Figure 3-10: Abundances of microarthropods at site 3

These abundance data can be considered as being characteristic for the typical tundra subzone, where normally about 35,000 ind • m^{-2} can be recorded (CHERNOV 1997). All in all, an increase of the total abundance of microarthropods within the northern tundra zones and a decrease of the proportion of oribatid mites can be discovered (BABENKO 1995).

In general, higher abundance of soil microarthropods can be found at site 3 compared with site 2. Moreover, the quantity of big-sized species and individuals of oribatid mites is higher at site 3, where the moss-layer and the layer of dead plant-material is thicker compared with site 2. Furthermore at site 3 microarthropods can be registered in quite high abundance even in deeper soil layers.

First results of the bait-lamina-test (not presented here) indicate a good correlation between microarthropod size and abundance as well as the feeding activity in different soil layers.

3.6.3 Ornithological observations

(Diana V. Solovieva)

The study of bird ecology and distribution was focused on breeding success related to the number of lemmings in late July - August 1998. The observed areas were the northern and southern parts of the Lena-Delta. The study is included in the long-term avifaunistic research, started at the Lena-Delta State Reserve in 1986.

3.6.3.1 Methods

Bird observations were made during land surveys both by feet and by motorboat at the islands and channels of the Lena-Delta. Altogether, we walked 60 km and moved for 670 km by boat. Species, sex and age of birds were identified. Breeding success was considered as being positive for those species which have been observed hatching and brooding their young. Other common breeders without offspring were considered as a failure in breeding at the season.

Lemming density was semiquantitively estimated throughout the season, and divided into four categories: *none*, *low*, *middle* and *high*.

We caught birds with mist-nets at Tit-Ary Island and ringed them with standard aluminium rings. Measurements of wing-, bill-, tarsus length and body weight were taken from birds while ringing, we also estimated the fat amount according to marks scales (see Table 3-8). Blood samples were taken for future DNA-analyses (kept now in the collection of Zoological Institute of St. Petersburg).

3.6.3.2 Results

We registered 32 bird species of 7 orders during thestudy period at both northern and southern parts of the Lena-Delta (see Table A3-4). Twenty nine breeding species were found in the study area, 25 species of which were successful in breeding. The remaining bird species had no breeding success due to low lemming density. The lemming density in the northern part of the delta was low, in the southern part of the delta the lemming density could be estimated as *low* to *middle*. Therefore the miophagial Rough-legged Buzzard had breeding success in the south.

Breeding success of waterfowl Bean Geese was also related to considerably high numbers of lemmings. The consequence of the low Lemming density in the North compared to the South was a failure of the brood for the Long-tailed Ducks, King and Steller's Eider. They loose their clutches before hatching due to predation. No single brood of the above mentioned species could be observed. In non-lemming years clutches and juvenile birds of waterfowl, waders, and gulls became the main food for mammalian and avian predators in the tundra. This sometimes leads to complete failure in breeding. A few species however (Red- throated Loon, Bewick's Swan, Herring and Glaucous Gulls), were found which defend their clutches and offspring from predation. Breeding success of Bewick's Swan was restricted by predation on clutches during early incubation period. The breeding success might be estimated about 10-20 %.

Facility of large Larids (Herring and Glaucous Gulls) for clutch protection against Arctic Fox (Alopex lagopus) seems to be related to the nesting density in colonies. Loose colonies with distances between nests of 20 - 50 m (Khardyrgastaakh and Biir-Balaganaakh Islands) and separate nesting pairs (Sagastyr and Kytaakh Islands) loose all clutches before hatching, while in the compact colony at Allara-Mayak Island with distances between nests of 2 -3 m at least 50 % of the Larids were successful in hatching.

Table 3-8: Wing length, weight and fat in passerine birds ringed at Tit-Ary Island, Lena-Delta, August 1998

Species	Sex	Age	Date	Wing length	Weight	Fat
				[mm]	[g]	mark
Oenanthe oenanthe	?	juv	01.08.98	96	24	-
Oenanthe oenanthe	?	juv	01.08.98	99	25	1
Oenanthe oenanthe	?	juv	01.08.98	96	24	0
Oenanthe oenanthe	?	juv	02.08.98	98	26	0
Oenanthe oenanthe	?	juv	02.08.98	101	29	4
Oenanthe oenanthe	F	ad	02.08.98	96	22	4
Motacila alba	?	juv	01.08.98	93	28	0
Calcarius lapponicus	F	ad	02.08.98	89	-	0
Anthis cervinus	?	juv	02.08.98	83	19	0
Cyanosilvia svecica	?	juv	03.08.98	74	17	0
Cyanosilvia svecica	?	juv	05.08.98	72	18	0

Birds whose nests are associated with the above mentioned compact Gulls colony, had breeding success. The only pairs which had breeding success among Brent Geese, Sabine's Gulls, and Red-throated Loons are those nesting together with the gulls colony. However, large Gulls are also egg and chick predators for conspecific and intraspecific neighbours. Gulls predation led to destruction of Eiders and Long-tailed Ducks nests even within compact Gulls colony.

The presence of lemmings considerably decreased predation pressure on clutches and broods in the southern part of the delta. In this area, not only wader species had nesting success, but also long-tailed ducks, whose breeding was a failure in the northern part of delta. Supposedly, passerine birds aren't affected by the numbers of lemmings and the connected predation pressure, they bred successfully everywhere in the delta (see Table A3-4 for the southern part).

3.6.4 Distribution and Abundance of Birds on the Channels of the Lena Delta

(V.I. Pozdnyakov)

3.6.4.1 Introduction

Birds are an important component of the ecosystem, that strongly reacting on any kind of change. Long-term monitoring of the status of bird populations allows to reveal the influences and consequences of environmental changes on the vital ecosystem components. For these purposes in accordance with the Russian-German program "System of the Laptev Sea-2000" we conducted the investigations of distribution and abundance of birds on the channels of the Lena Delta during the period from the 15 June to 25 July 1998.

The main objects of study were:

- determination of species composition of birds, inhabiting the channels of the Lena Delta;
- preliminary estimate of abundance of bird populations;
- total estimate of the character and the revealing of the distribution patterns of species in a concrete season;
- the revealing of the concentration sites of separate species or ecological groups.

3.6.4.2 Methods and materials

In the Lena Delta the observations were carried out from motor boats on the channels. Despite some errors this method is the cheapest and it allows to observe the bird populations within the vast territories of wetlands during a short period of time. The surveys were carried out from the motor boat. The birds were counted within maximum visibility, rarely exceeding 500 m from each side of the channels for the largest species (swans, geese, loons, large gulls). On the narrow channels this distance was smaller and determined by the channel width. In order to specify the species as well as the age structure of the birds 12x and 20x binoculars were used. Survey results were estimated as individuals per 10 km channel. The length of routes was measured on a map (scale 1:100,000). The total length routes was 1609 km. Taking into account that the various areas of the Lena Delta can be distinguished by the landscape and by physico-geographic characteristics, we divided the study area into the following sites:

1. channel sites in the southern part of the Lena Delta, joining the principal channel. 72° 24' - 72° 36' N; 125°25' - 127°O' E. The records were counted on 24, 26, 29 June and 7, 19, 20, 24, 25 July. Total length of routes was 251 km.
2. the southern part of the Arynskaya Channel up to 72°50' N. The record was conducted on 20 June. The length of route was 39 km.
3. the channels between the southern parts of the Arynskaya and the Malaya Tumatskaya Channels up to 72°54' N. The record was conducted on 20 July. The length of route was 38 km.
4. the channels between the southern parts of the Malaya and the Bolschaya Tumatskaya Channels up to 72°54' N. The record was conducted on 21 July. The length of route was 27 km.
5. the channels between the northern parts of the Malaya and Bolschaya Tumatskaya Channels, north from 72°54' N. The records were conducted on 22 and 23 July. The length of routes was 85 km.
6. the northern part of the Malaya Tumatskaya Channel, north from 73°10'. The record was conducted on 22 July. The length of route was 60 km.
7. the southern part of the Bolschaya Tumatskaya Channel up to 72°54' N. The records were counted on 29 June and 23 July. The length of routes was 114 km.
8. the northern part of the Bolschaya Tumatskaya Channel, north from 72°54' N. The records were conducted on 29 June and 4, 21, 23 July. The length of routes was 192 km.
9. the channels between the Bolschaya Tumatskaya and Bolschaya Trofimovskaya Channels, north from72°45' N. The records were conducted 4 and 5 July. The length of routes was 177 km.
10. the channels between the Bolschaya Trofimovskaya and Bykovskaya Channels, south from 72°45' N. The record was conducted on 6 July. The length of routes was 116 km.
11. The Bykovskaya Channel. The records were conducted on 15, 19 June and 2, 3, 7, 8, 18 July. The length of routes was 510 km.

3.6.4.3 Results and discussion

During the whole observation time 32 bird species were registered. The average density of birds on the channels of the Lena Delta was 9,77 individuals per 10 km channel. As the observations carrie out simultaneously to the nesting period, on the channels mainly non-breeding birds were recorded. The highest density could be found on the small channels of the southern part of the delta, approximately up to 73° N (Table A3-5). Meandering channels and numerous shallow sites create favourable protective and feeding conditions for waterfowl. The large channels -at that time - are considerably less inhabited as they are unprotected against pretty strong winds. The lowest bird abundance but a high species diversity (18 species) was registered on the Bykovskaya Channel (site 11). The Bykovskaya Channel is one of the main routes of spring bird migration to the Lena Delta.

Loons. Two species of *Gavia arctica* and *G. stellata* were observed. Both species inhabit the study area rather evenly. The highest abundance was registered in the northern part of interfluve of the Malaya and Bolschaya Tumaskaya Channels (site 5). We didn't observe considerable domination of one species over another.

Geese. Only two species of Geese, *Anser albifrons* and *A. fabalis*, were observed. The abundance of *A. albifrons* was considerably higher, especially in the eastern part of the delta (sites 9, 10). In the area between the Bolschaya Trofimovskaya and Bolschaya Tumatskaya Channels this species was predominant. On the 4 and 5 July we recorded rather large (up to 37 inv.) flocks of non-breeding geese that preparing to molt. *A. fabalis* is more often visible in the southern part of the delta. The brood of 3 chicks of this kind of geese was found at site 1 on 19 June.

Swans. It is known that the Lena Delta is a habitat of *Cygnus cygnus* and *C. bewickii*, but we observed only *C. bewickii*. The highest abundance of this species was registered in the interflow of Arynskaya and Bolschaya Tumatskaya Channels (site 3, 4, 5). In the southern part of interfluve of Malaya and Bolschaya Tumatskaya Channels only the large gulls exceed this species in number. On 20-23 July there were 1 to 4 chicks in 6 broods we found.

Ducks. The abundance of ducks in the nesting period on the channels was low. The birds prefer the lake systems of the islands as habitat. *Clangula hyemalies* was found almost everywhere in small numbers. Non-breeding *Somateria spectabilis* and *Polysticta stelleri* are more common in the northern part of the delta, especially in the seaside areas.

Predators. Specialised miophags (*Buteo lafopus, Nyctea scadiaca*) were rare in the Lena Delta during the observation period. The reason for that was a low number of lemmings in this season. *Falco pelegrinus* was found only on the Bykovskaya Channel (site 11), nesting on the rocky riverside precipices.

Ptarmigans. Both species of ptarmigans (*Lagopus lagopus, L. mutus*) are inhabiting the delta. They were registered on the channels only accidentally

Warders. Warders were observed on the channels of the Lena Delta only during the migration time. In the second half of June *Phalaropus fulicarius, Philomachus pugnax, Calidris minuta, C. melanotos* were found on the Bykovskaya Channel (site 11). In late June - early July migratory flocks of females of *Ph. fulicarius* were registered in the northern parts of the delta.

Skuas. In the northern part of site 9 an accumulation of non-breeding *Stercorarius londgicaudus* was recorded. The abundance of *St. pomarinus* and *St. parasiticus* was low. The reason for this was the low lemming density.

Large gulls. This group is the most typical inhabitant of the Lena Delta channels. It prevailed in numbers over the other bird groups. Some higher abundance was observed in the southern part of the delta (site 4). Local accumulations of gulls were observed near fishing sites (site 1). In general, the numbers of *Larus argentatus* was higher than the numbers of *L. hyperboreus.*

Small gulls and terns. In the delta, the distribution of *Sterna paradisaea* was much higher than for other species of this group. Nevertheless its abundance is not high. *Rhodostetia rosea* and *Xema sabini* can be more frequently found in the northern part of the delta. The flocks of non-breeding *Rh. rosea*, including immature individuals, were observed on 6 July in the northern part of site 10. The same day, but not during the surveys, a flock of approximately 500 birds was registered.

Passerines. *Plekrophenax nivalis* builds the nests in the peat precipices of island shores. Therefore, this species was frequently found on the channels of the delta.

3.7 Further investigations

(E.-M. Pfeiffer)

The most interactions between trace gas fluxes and permafrost soil dynamics are expected for the thawing and refreezing periods. During the next expedition the measurements of the gaseous carbon losses (CO_2, CH_4) and the energy and water fluxes have to be extended to the winter season and the transition time. Further field studies will be done on the methane production and emission of selected lake and river sites and their sediments. Carbon isotope measurements will be used to differentiate biogenic and thermogenic methane of important compartiments in the Lena Delta landscape. Correlation between the recent soil properties/pedogenic processes and the features of paleosoils of selected permafrost sites will be used as a contribution to the reconstruction of the paleoenvironment. All research work will be done in close co-operation with Russian and German partners.

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3.9 Appendix

Table A3-1: List of samples TP 1

Number	Samples	Planned Analyses
LS 98 6000 - 6021	Soil samples of each horizon of Profile 1a (measurement site)	chemical, microbiological, physical
LS 98 6022 - 6032	Soil samples of each horizon of Profile 1b (measurement site)	chemical, microbiological, physical
LS 98 6033 - 6042	Soil samples of each horizon of Profile 2 (measurement site)	chemical, microbiological, physical
LS 98 6043 - 6050	Soil samples of each horizon of Profile 4 (measurement site)	chemical, microbiological, physical
LS 98 6087 - 6092	Soil samples of each horizon of Profile V11 (transect)	chemical, physical
LS 98 6093 - 6095	Soil samples of each horizon of Profile V2 (transect)	chemical, physical
LS 98 6111 - 6114	Soil samples of each horizon of Profile Kuringnak-Sise 1	chemical, physical
LS 98 6115 - 6119	Soil samples of each horizon of Profile Kuringnak-Sise 3	chemical, physical
LS 98 6142 - 6143	Soil samples of each horizon of Profile W7a (transect)	chemical, physical
LS 98 6144 - 6145	Soil samples of each horizon of Profile W7b (transect)	chemical, physical
LS 98 6146 - 6147	Soil samples of each horizon of Profile W4 (transect)	chemical, physical
LS 98 6148 - 6161	Plant material of several Sites	chemical, physical

Table A3-2: Precipitation and water samples (B: well; K: suction lysimeter; example: K 21 is suction lysimeter NR. 1 at site 2.)

Nr.	Date	Location	LF (µS/cm)	pH	Isotope	Anion	Cation
1	24./25.07.98	Rain			x		
2	28./29.07.98	Rain			x		
3	29.07.98 13:05	B 2			x	x	x
4	29.07.98 13:20	K 21	230	7,1	x	x	x
5	29.07.98 22:30	K 22	170	6,6	x	x	x
6	31.07.98 16:15	B 2	180	6,4			
7	03.08.98 14:15	B 2	187	6,7			
8	03.08.98 14:00	B 3	420	6,3			
9	03.08.98 22:00	K 21	247	7	x	x	x
10	04.08.98 10:00	K 33	151		x	x	x
11	04.08.98 10:00	K 35	216	7,1	x	x	x
12	07.08.98 12:00	B 2	165	6,8			
13	07.08.98 11:45	B 3b	163	6,4			
14	07.08.98 12:30	B 4	366	6,6			
15	07.08.98 22:00	K 21	241	6,9	x	x	x
16	07.08.98 22:00	K 22	168	6,7	x	x	x
17	07.08.98 22:00	K 31	202	7,2	x	x	x
18	07.08.98 22:00	K 32	196	7	x	x	x
19	07.08.98 22:00	K 33	172	7	x	x	x
20	07.08.98 22:00	K 35	243	7,2	x	x	x
21	07.08.98 22:00	K 44	428	7,2	x	x	x
22	07.08.98 22:00	K 43	416	7	x	x	x
23	07.08.98 22:00	K 42	407	6,9	x	x	x
24	07.08.98 22:00	K 41	349	6,9	x	x	x
25	10.08.98 15:40	B 2	263	7,2			
26	10.08.98 16:30	B 4	360	6,8			
27	13.08.98 12:00	B 2	248	7,1			
28	13.08.98 11:30	B 3b	295	6,6			
29	13.08.98 11:30	B 3a	180	7			
30	13.08.98 12:30	B 4	360	6,7			
31	13.08.98	Rain			x		
32	14.08.98 22:00	K 21	258	7,7	x	x	x
33	14.08.98 22:00	K 22	169	7,5	x	x	x
34	14.08.98 22:00	K 31	149	7,7	x		
35	14.08.98 22:00	K 32	175	7,4	x	x	x
36	14.08.98 22:00	K 33	203	7	x		
37	14.08.98 22:00	K 35	275	7,8	x		

Table A3-2: continuation

Nr.	Date	Location	LF (µS/cm)	pH	Isotope	Anion	Cation
38	14.08.98 22:00	K 41	321	7,4	x	x	x
39	14.08.98 22:00	K 42	416	7,6	x	x	x
40	14.08.98 22:00	K 43	440	8,4	x		
41	14.08.98 22:00	K 44	419	8,3	x		
42	15.08.98 15:50	B 2	275	6,7			
43	15.08.98 15:30	B 3b	329	7			
44	15.08.98 15:30	B 3a	227	7			
45	15.08.98 16:15	B 4	374	7			
46	17.08.98	K 21	247	7			
47	17.08.98	K 22	169	7,1			
48	17.08.98	K 31	147	7,2			
49	17.08.98	K 32	198	7,1			
50	17.08.98	K 33	205	7,2			
51	17.08.98	K 35	291	7,3			
52	17.08.98	K 41	322	7,1			
53	17.08.98	K 42	384	7,1			
54	17.08.98	K 43	456	7,4			
55	17.08.98	K 44	427	7,3			
56	17.08.98 11:30	B 2	258	6,8			
57	17.08.98 11:00	B 3b	400	6,7			
58	17.08.98 11:00	B 3a	231	6,7			
59	17.08.98 12:00	B 4	405	6,7			
60	20.08.98 13:00	B 2	294	7,2			
61	20.08.98 11:00	B 3b	467	7			
62	20.08.98 11:00	B 3a	220	6,9			
63	20.08.98 13:30	B 4	388	6,9			
64	20.08.98 17:00	K 43	444	7,6	x		
65	20.08.98 17:00	K 42	388	7,5	x		
66	20.08.98 17:00	K 41	313	7,1	x		
67	20.08.98 17:00	K 21	247	7	x	x	x
68	20.08.98 17:00	K 23	153	7,2	x		x
69	20.08.98 17:00	K 31	135	7,3	x		
70	20.08.98 17:00	K 32	201	7,2	x		
71	20.08.98 17:00	K 33	218	7,2	x		
72	20.08.98 17:00	K 35	290	7,5	x		
73	20.08.98 17:00	K 44	418	7,8	x		

Table A3-3: List of species of the different measurement sites (Site 1 - 3). 1 + 3: low centred polygon; a: centre of the polygon; b: border of the polygon; 2: sand wedge polygon

	1 a	1 b	2	3 a	3 b
Alopecurus alpinus			x		
Antennaria friesiana			x		
Antennaria lanata		x	x		
Arctagrostis arundinacea		x	x	x	x
Arctous alpina			x		
Arctous erythrocarpa		x			x
Armeria maritima			x		
Artemisia furcata			x		
Astragalus alpinus			x		
Astragalus umbellatus		x			x
Caltha arctica				x	
Caltha caespitosa				x	
Cardamine digitata					x
Carex concolor	x		x	x	
Carex maritima			x		
Castilleja pallida			x		
Comarum palustre	x				
Coeloglossum viride			x		
Deschampsia borealis	x				
Dryas octopetala		x			
Dryas punctata			x		
Dupontia psilosantha				x	
Festuca richardsonii		x			
Hedysarum arcticum		x	x		
Hieracium pauciflorum					
Koeleria asiatica			x		
Lagotis minor			x		
Luzula confusa		x	x		
Luzula multiflora					x
Luzula nivalis		x			
Luzula tundricola			x		x
Minuartia arctica			x		
Myosotis asiatica			x		
Endocellion sibiricum			x		
Achoriphragma nudicaule			x		
Orthilia obtusata			x		
Oxytropis middendorffii			x		
Oxytropis vassilchenkoi			x		
Parnassia palustre			x		
Pedicularis lanata		x	x		
Pedicularis oederi			x		
Pedicularis sudeticainterioroides	x		x	x	x
Pedicularis verticillata			x		
Pedicularis villosa		x			
Poa paucispicula		x			

Table A3-3: continuation

	1a	1b	2	3a	3b
Poa arctica					x
Bistorta major			x		
Bistorta elliptica					
Aconogonon tripterocarpum					
Bistorta vivipara			x		
Rumex acetosa			x		
Salix glauca	x	x	x		x
Salix nummularia		x	x		
Salix pulchra					x
Salix reptans				x	
Sanguisorba officinalis			x		
Saussurea tilesii			x		
Saxifraga hieracifolia			x		
Saxifraga hirculus			x		
Saxifraga nelsoniana			x		
Tanacetum bipinnatum			x		
Tofieldia coccinea			x		
Tofieldia pusilla			x		
Trisetum sibiricum			x		
Trisetum litorale		x			x
Vaccinium uliginosum		x			
Valeriana capitata			x		
Aulacomnium palustre	x	x		x	x
Aulacomnium turgidum		x			x
Bryum pseudotriquetrum				x	
Bryum sp.				x	
Calliergon giganteum	x			x	
Calliergon megalophyllum				x	
Campylium stellatum				x	
Campylium sp.				x	
Cinclidium latifoilium				x	
Cirriphyllum cirrosum				x	
Climacium dendroides		x			x
Distichium capillaceum		x			
Ditrichum flexicaule					
Warnstorfia exannulata				x	
Limprichtia revolvens				x	
Sanionia uncinata		x			
Hamatocaulis vernicosus	x			x	
Drepanocladus sp.				x	
Eurhynchium pulchellum		x			
Hylocomium splendens	x	x			x
Lophozia ruthiana (Hepaticae)				x	
Meesia longiseta				x	
Meesia triquetra				x	
Meesia uliginosa		x			
Timmia austriaca var.arctica		x			x

Table A3-3: continuation

	1 a	1 b	2	3 a	3 b
Tomentypnum nitens	x	x			x
Biatora sp.			x		
Cetraria islandica			x		
Cetraria laevigata					x
Cladonia pocillum			x		
Cladonia pyxidata		x	x		x
Cladonia "squamosa"			x		
Cladonia spp.			x		
Dactylina arctica			x		x
Dactylina ramulosa			x		
Flavocetraria cucullata			x		x
Flavocetraria nivalis			x		
Lecanora epibryon			x		
Leptogium saturninum			x		
Leptogium "tenuissimum"			x		
Lobaria linita			x		
Nephroma expallidum			x		
Ochrolechia sp.			x		
Pannaria pezizoides			x		
Pannaria praetermissa			x		
Peltigera aphthosa		x	x		x
Peltigera didactyla		x	x		
Peltigera rufescens			x		x
Peltigera scabrosa	x				x
Peltigera sp. (glossy)			x		
Peltigera venosa			x		
Psoroma hypnorum			x		
Solorina sp.			x		
Stereocaulon alpinum			x		
Sticta arctica			x		
Thamnolia vermicularis			x		

Table A3-4: Bird species, Lena-Delta, mid-July - August 1998

Species name	Latin name	Northern part of the delta	Southern part of the delta
Black-throated Loon	Gavia arctica	Br	+
Red- throated Loon	G. stellata	Br	+
Bewick*s Swan	Cygnus bewickii	Br	+?
Brent Goose	Branta bernicla	Br	-
Bean Goose	Anser fabalis	-	Br
King Eider	Somateria spectabilis	Br	-
Steller´s Eider	Polysticta stelleri	Br	-
Long-tailed Duck	Clangula hyemalis	+	Br
Rough-legged Buzzard	Buteo lagopus	-	Br
Merlin	Falco columbianus	-	+
Willow Ptarmigan	Lagopus lagopus	Br	Br
Turnstone	Arenaria interpres	Br	Br
Temminck`s Stint	Calidris temminckii	-	Br
Wood Sandpiper	Tringa glareola	-	Br
Sabine`s Gull	Xema sabini	Br	-
Herring Gull	Larus argentatus	Br	+
Glaucous Gull	L. hyperboreus	Br	+
Snowy Owl	Nyctea scandiaca	+	-
Barn Swallow	Hirundo rustica	-	Br
Red-throated Pipit	Anthus cervinus	-	+
White Wagtail	Motacilla alba	-	Br
Red-winged Thrush	Turdus illiacus	-	Br
Eastern Naumann`s Thrush	Turdus eunomus	-	+
Northern Wheatear	Oenanthe oenanthe	-	Br
Bluethroat	Cyanosilvia svesica	-	Br
Willow Wabler	Phylloscopus trochilis	-	Br?
Siberian Accentor	Prunella montanella	-	Br
Little Bunting	Emberiza pussila	-	Br
Pallas*s Red Bunting	E. pallasi	-	Br
Lapland Longspur	Calcarius lapponicus	+	Br
Snow Bunting	Plectrophenax nivalis	Br	+
Redpool	Acanthis flammea	-	Br

Br = breeding species; + = species was observed with unknown status;
- = no observation of the species.

Table A3-5: Abundance of birds in the channels (inv./10km) of the different sites of the Lena Delta. See Chapter 3.6.4 for the sites definitions.

Site	1	2	3	4	5	6	7	8	9	10	11
Distance surveyed (km)	251	39	38	27	85	60	114	192	177	116	510
Species											
Gavia arctica	0,12	0,00	0,53	1,11	0,35	0,00	0,00	0,42	0,51	0,00	0,00
Gavia stellata	0,12	0,00	0,26	0,37	0,71	0,00	0,00	0,00	0,62	0,00	0,00
Gavia sp.	0,32	0,26	1,05	0,37	1,18	1,00	0,00	0,63	0,62	1,20	0,02
Anser albifrons	0,00	0,00	0,00	0,74	0,00	0,00	0,00	0,42	6,44	2,33	0,00
Anser fabalis	0,20	0,00	0,00	0,37	0,00	0,00	0,53	0,00	0,00	0,52	0,00
Cygnus bewickii	0,16	0,51	4,74	11,11	2,59	0,50	0,98	0,36	1,81	1,90	0,04
Anas acuta	0,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,69	0,20
Clangula hyemalis	0,12	0,26	0,80	0,74	0,00	0,00	0,00	0,26	0,17	0,17	0,18
Somateria spectabilis	0,00	0,00	0,26	0,00	0,00	0,00	0,00	0,83	0,90	0,26	0,06
Polysticta stelleri	0,00	0,00	0,26	0,00	0,00	0,00	0,00	0,63	0,11	0,69	0,00
Melanitta deglandi	0,00	0,00	0,00	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00
Buteo lagopus	0,12	0,00	0,53	0,00	0,00	0,00	0,00	0,05	0,00	0,09	0,00
Falco peregrinus	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02
Nyctea scandiaca	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,05	0,00	0,00	0,00
Lagopus lagopus	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00
Lagopus mutus	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02
Pluvialis squatarola	0,00	0,00	0,26	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,00
Phalaropus fulicarius	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,35	0,56	0,00	0,61
Philomachus pugnax	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02
Calidris minuta	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,17	0,00	0,08
Calidris tamminckii	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,00	0,00
Calidris alpina	0,00	0,00	1,58	0,00	0,00	0,00	0,00	0,36	0,00	0,00	0,02
Calidris melanotos	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,25
Wader sp.	0,00	0,00	0,80	0,00	0,00	0,00	0,00	0,31	0,00	0,00	0,00
Stercorarius pomarinus	0,00	0,00	0,00	0,00	0,12	0,00	0,00	0,16	0,00	0,00	0,06
Stercorarius parasiticus	0,00	0,51	0,00	0,00	0,00	0,00	0,09	0,10	0,06	0,00	0,00
Stercorarius longicaudus	0,00	0,00	0,00	0,00	0,00	2,83	0,00	0,05	5,08	0,00	0,00
Stercorarius sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02
Larus argentatus	1,39	5,90	12,37	18,52	2,12	1,00	1,05	1,82	2,82	5,52	0,45
Larus hyperboreus	0,80	1,28	0,53	4,07	0,24	0,83	0,18	0,63	0,62	0,52	0,22
Larus sp.	4,26	0,00	0,00	5,93	0,00	0,00	4,12	0,00	0,00	0,00	0,00
Xema sabini	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,34	0,00	0,00
Rhodostetia rosea	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,06	3,79	0,00
Sterna paradisaea	0,00	0,00	1,32	1,58	0,00	0,00	0,26	0,42	0,68	1,47	0,22
Plectrophenax nivalis	0,00	0,00	4,74	0,37	0,00	0,00	0,00	0,05	0,11	0,00	0,29
Anthus sp.	0,00	0,00	1,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total birds	7,69	8,72	31,32	45,56	7,41	6,17	7,19	8,91	21,86	19,14	2,76

List A3-1: Description of the soils along the transects of Samoylov Abbreviations see end of List A1 (for the position of the transects t, v, and w see also figure 3-1)

t1 03.08.98 AMG High flood-plain.

I	0-2 cm	S. yg with mud at the very top.
II	2-10 cm	S. bluish-grey, muddied. M., the plant remains: a little.
III	10-21 cm	S. grey, int. peated (P moss-grass, by L.), int. muddied. M.
IV	21-25 cm	P. yellowish-gb, moss, l., int. muddied. W.
V	25-58 cm	l. grey W. thick layer: S., mud, P.
VI	58-64 cm	S. blue-grey, muddied. W, the plant remains: a little. Pf below.

t2 03.08.98

Between the channel and the lake. The surface is rather drained, lakes are absent, but polygons are wet, water is from 0. There is sand on the surface.

t2a 03.08.98 PG

The centre of the polygon. P. is standard.

T1	0-13 cm	P. sl dc, d-gb, moss, W.
T1	13-29 cm	P. sl dc, gb, grass-moss, sanded. W. Pf below.

t2b. 03.08.98 PshG

Middle part of axis.

Tv	0-1 cm	Lm sanded.
To	1-3 cm	Llm d-gb, middle sanded.
T1	3-11 cm	P sl dc, d-gb, l., sl. sanded. M.
ABg	11-23 cm	Ls grey with blue-grey and rusty spots, muddied, sl l., lenses of S. M., the plant remains: middle quantity.
G	23-26 cm	Ls blue-grey, int. muddied. W., the plant remains. Pf below.

t3/2 02.08.98 PG

Lake basin, to the south of transect. Polygons, there is standard P in the polygon, Pf is at a depth of 32cm. Axes are wet, there is P. in axes, Pf is at a depth of 18cm.

t3 02.08.98 PG

Lake basin, 4m to the east of the lake. Water is at a depth of 3-5cm. P. is standard.

T1	0-13cm	P sl dc, d-gb, moss. W.
T1	13-26cm	P sl dc, gb, grass-moss, sanded, W. Pf below.

t4a 02.08.98 PG

Polygons are wet, water is above mosses. It is not possible to make pit, but we can say, that P. is standard. Pf is at a depth of 36cm (from level of water).

t4b 02.08.98 PshG

Flat axis (axes are flat on the whole).

Tv	0-1cm	Lm.
T01	1-6cm	Llm - P sl dc, d-gb, sl sanded, M.
T1	6-12cm	P. sl dc, d-gb, grass-moss, sl sanded, l. M.
TAg	12-14cm	P. brown-grey, l., int. h, int. muddied, sl sanded. M.
Bfeg	14-15cm	Rusted horizon: Loam coarse yellow-rusty with blue-grey
spots,		int. muddied. M.

List A3-1: continuation

TG 15-18cm P grey, grass, int. muddied, sanded, compressed, l. M.
Pf below.

t4c 02.08.98

Elevation in a corner of axes. The pit is rather unusual.
Tv 0-1cm Lm.
T1 1-7cm P sl dc, d-gb, sl sanded, l. M, interlocked by living roots.
A 7-12cm Ls d-grey, muddied, l. M., the plant remains (P.).
BG 12-15cm Ls - coarse Loam, grey with greenish spots, muddied, l. M., the plant remains: a little.
Bg 15-19cm Ls grey, less gley. int. muddied, l. M., the plant remains.
G 19-23cm Loam coarse, blue-grey with yellow spots, int. muddied, l. M., the plant remains: rather a lot.
CG 23-30cm Ls grey with blue-grey and rusty-yellow spots, int. muddied, l. M., the plant remains: a lot.
Pf below.

t5a 02.08.98 PG

Polygons are irregular, wet, with lakes in about 50%. The centre of a polygon. The pit is standard.
T1 0-14cm P d-gb, moss, sl dc, loose, but interlocked by roots of sedges, sl l. W.
T1-2 14-34cm P grey-brown, moss-sedge, middle - sl dc, clearly l., compressed, ils of mud and S. W.
Pf below.

t5b 02.08.98 PshG

Flat axis. Axes in part are lowered almost down to level of polygons. The pit is standard.
Tv 0-1cm Lm.
To 1-5cm Llm gb, sanded. M.
T1 5-10cm P gb, moss, sl dc, sl sanded. :Loose, but interlocked by roots of sedge, M.
ABg 10-13cm Ls grey, separate rusted spots. Muddied, M., the plant remains.
Bfeg 13-14cm Rusted horizon: coarse loam yellow-rusty with blue-grey spots, int. muddied. M.
TG 14-20cm P grey, grass, int. muddied, sanded, compressed, l. M.
Pf below.

t6 01.08.98

Practically all the centres of polygons have little lakes, water is above mosses. The surface between lakes is rather flat, but there are some elevations.

t6a 01.08.98 PG

The centre of a polygon. Water is from 0 cm. It is not possible to reach Pf.

t6b 01.08.98 PshG

Flat axis.
Tv 0-1cm Lm.
T01 1-7cm P moss sl dc - lifeless moss, d-gb, loose, very sl l., dusted by S. M.
T2 7-16cm P d-gb, grass-moss, middle dc, l., compressed, sl sanded and sl muddied. M.
Bfeg 16-17cm Very bright rusty strip: Ls muddied, sanded, peated. almost W.

List A3-1: continuation

TG	17-20cm	P grey, int. muddied, l., L. are dense, interlocked by living and lifeless roots. M. Pf below.

t6c 01.08.98 TG

Elevation on the flat axis.

Tv	0-1cm	Lm.
To	1-3cm	Llm gb, sanded. M.
T1	3-7cm	P gb, moss, sl dc, sl sanded. Loose, but interlocked by roots of sedge. M.
TA	7-12cm	P brown-grey, h., muddied, sanded (just more mineral horizon, than P.), l. M.
ABg	12-19cm	Ls grey, separate rusted spots. Muddied. M., the plant remains.
Bfeg	19-21cm	Rusted horizon: coarse loam yellow-rusty with blue-grey spots, int. muddied. M.
TG	21-30cm	P grey, grass, int. muddied, sanded, compressed, l. M.
G	30-32cm	S. bluish-grey with rusty spots, muddied, the plant remains: a little. Pf below.

t7 01.08.98

Polygons are rather flat, there are many little lakes, in part merged together. Polygons are small and irregular. Axes are wide, flat, but there are more expressed.

t7a 01.08.98 PG

The centre of polygon.

Tv	0-1cm	Lm
T11	1-5cm	P d-gb, moss, sl dc, non-l., but crushed and compressed, sl sanded. W.
T12	5-13cm	P gb, grass-moss, more light, than horizon above, l., compressed, sl sanded. W.
T2	13-30cm	P grey-brown, grass, middle dc, l., compressed, ils of muddied S. W. Pf below.

t7b 01.08.98 PshG

Flat axis.

Tv	0-1cm	Lm.
To	1-4cm	Llm d-gb, loose.
T2	4-12cm	P d-gb, moss, middle dc, l., muddied and sanded. M.
ABg	12-17cm	Ls bluish-grey, l., h, muddied. M. The plant remains. There are rather large remains between them.
BfeG	17-18cm	S., int. muddied, less h., clear rusty spots about 50%. M., the plant remains.
TG	18-21cm	P grey, int. muddied, l., L. are dense, interlocked by living and lifeless roots. M. Pf below.

t8a 01.08.98 PG

Polygons are irregular (our polygon is triangle with sides about 12m). Structure is analogous to pits 9a, 10a, 11a. Pf from 29 cm, but very int. interlocking by roots.

t8b 01.08.98 TG

Axis of polygon.

List A3-1: continuation

Tv	0-1cm	Lm.
TA	1-9cm	P d-grey-brown, int. muddied and sanded. M., interlocked by living roots. There is S. lens on the boundary of horizons.
ABg	9-15cm	Ls bluish-grey, sl l. (S. + Md + humus). M., the plant remains: a little.
BGfe	15-16cm	S. (more sandy horizon, than ABg), int. muddied, less h., clear rusty spots about 50%. M., the plant remains.
TG	16-21cm	P grey, int. muddied, l., L. are dense, interlocked by living and lifeless roots. M. Pf below.

t8c 01.08.98 TG

Elevation in a corner of axes.

Tv	0-2cm	Lm.
Tv	2-6cm	Llm light-gb, loose, sl sanded. Fr.
TA	6-11cm	P grass grey-brown, h., sanded, muddied, l., compressed. M.
ABg	11-16cm	S. - Ls grey, muddied, h. M., the plant remains: middle quantity. Transition to the lower horizon is crooked, cryoturbated, but clear.
Bfeg	16-18cm	Ls rusty-grey with yellow spots, int. muddied. M., the plant remains: little.
T2B	18-20cm	P gb, middle dc, int. muddied, l., compressed. M.
G	20-22cm	Ls blue-grey, int. muddied. M., the plant remains.
T1-2G	22-29cm	P brown-grey, int. muddied (Md bluish-grey), l., compressed. M. Pf below.

t9a 01.08.98 PG

The centre of polygon. Description of this pit is 1:1 with 11a and 10a. Pf from 31 cm.

t9b 01.08.98 TG

The corner of axes of polygon. Polygons on the whole are irregular, 10-13 m. The pit differs from another those.

Tvo	0-3cm	Lm - lifeless moss.
T2A	3-7cm	P d-grey-brown, middle dc, h., sl sanded and muddied, l., compressed. M.
ABg	7-18cm	S. - Ls grey, muddied, h. M., the plant remains: middle quantity. Transition to the lower horizon crooked, cryoturbated, but clear.
Bfeg	18-20cm	Ls rusty-grey with yellow spots, int. muddied. M., the plant remains: a little.
G	20-28cm	Ls bluish-grey, M. The plant remains: middle quantity. Pf below.

t10a 30.07.98 PG

The polygons are small, 7-10m, central part of polygon is 2.5-4m, little lakes are in about 50% polygons.

Tv	0-2cm	Lm.
T1	2-18cm	P d-gb, sl dc, moss, very sl sanded, practically non- l., only crushed. W.
T1	18-33cm	P gb, sl dc, sedge-moss, sl sanded and muddied, clearly l., com pressed. W. Pf below.

t10b 30.07.98 TG

Central part of axis.

List A3-1: continuation

Tv 0-1cm Lm.
To 1-6cm Llm d-gb, loose. M.
TA 6-8cm P d-grey-brown, int. muddied and sanded. M., interlocked by living roots.
ABg 8-14cm Ls bluish-grey, sl l. (S. + Md + humus). M., the plant remains: a little.
BGfe 14-15cm S., int. muddied, less h., clear rusty spots about 50%. M., the plant remains.
TG 15-20cm P grey, int. muddied, l., L. are dense, interlocked by living and lifeless roots. M.
G 20-23cm Blue-grey gley horizon: Md + the plant remains. l., M. Pf below.

t11 30.07.98

Thermokarst subsided hollow on the fluvial terrace above flood-plain.

t11a 30.07.98 PG

The centre of polygon. Water is from 0, Pf is from 38.
Tv 0-2cm Lm.
T1 2-20cm P d-gb, sl dc, moss, very sl sanded, practically non- l., only crushed. W.
T1 20-38cm P gb, sl dc, sedge-moss, sl sanded and muddied, clearly l., com pressed, W.
Pf below.

t11b 30.07.98 TG

The corner of axis, its the most elevated part. Polygons are wet, water is from 0, but not lakes.
Tv 0-1cm Lm.
To 1-5cm Llm d-gb, loose. M.
TA 5-10cm P d-grey-brown, int. muddied and sanded. M., interlocked by living roots.
ABg 10-18cm Ls d-grey, h, int. muddied (S. + Md = Ls), sl l. M.
BGfe 18-20cm S., int. muddied, less h., clear rusty spots about 50%. M., the plant remains.
G 20-25cm Ls - Md sl sanded, blue-grey, l. M., the plant remains: a lot.

t12 03.08.98 TG

On axis. Standard.
Tv 0-1cm
To 1-4cm
T1 4-6cm
ATg 6-11cm
BG 11-20cm
G 20-26cm Ls blue-grey with rusty spots.

t13 03.08.98

Fluvial terrace above flood-plain. Polygons are clearly expressed, with cracks. Polygons are wet, but there are no more 5% of typical lakes .

t13a 03.08.98 PG

The centre of sedge-moss polygon. P. is at a whole depth, Pf is at a depth of 34cm.

t13b 03.08.98 HG

Rather high axis.

List A3-1: continuation

Tv	0-1cm	Lm.
To	1-3cm	Llm d-grey, almost black, sanded, dry.
T1	3-6cm	P sl dc, d-gb, crushed, but non-l. M, sl interlocked by living roots.
T2(TA)	6-10cm	P brown-grey, l., int. sanded, muddied, non-dense. M.
ABg	10-13cm	S. grey, l., muddied. M., the plant remains: a lot.
	13-14cm	S. il. yellow-grey.
BG	14-28cm	Ls grey, l., peated, muddied, M.
G	28-30cm	Ls blue-grey, l., more mud, less the plant remains, M.

t14 03.08.98

High flood-plain. Almost flat, sl concave polygons with sides up to 18m, irregular. The centres of polygons are wet, water is from 0, but there are little lakes.

t14a 03.08.98 AMPG

The centre of polygon.

T1	0-15cm	P sl dc, d-gb, moss, l. W.
T1	15-33cm	P gb, moss with admixture of sedge, l., sl sanded and muddied. W.

t14b 03.08.98 AMPshG

The corner of polygons, the most elevated part of axes.

Tv	0-1cm	Lm.
To	1-3cm	Llm, almost black, sanded, M.
T1	3-7cm	P sl dc, gb (d-brown), sl. l., sl sanded, M.
T21	7-11cm	P middle dc, brown-grey, int. sanded, sl muddied, l., compressed, M.
I	11-12.5cm	Il. of S. greenish-grey, sl muddied, W. The plant remains: a little.
T22	12.5-16cm	= T21
Bfeg	16-17cm	S. gb-rusty with blue-grey spots. M., the plant remains.
G	17-23cm	Ls blue-grey, int. muddied, the plant remains: a lot.

t15 30.07.98 AMPshG

On axis.

Tv	0-0.5cm	Lm.
T1	0.5-16cm	P d-gb, sl dc, sl sanded, loose. M.
TG	16-17cm	P d-gb, almost black, with ils of bluish-grey S. W.
	Pf below.	

G 17-18cm S. bluish-grey, middle muddied. Frozen.

t16 30.07.98 AMPshG

Flat, without polygons, depressed part of middle flood-plain.

Tv	0-1cm	Lm.
T1	1-15cm	P gb, sl dc, loose, l. only in lower part. M.
Bg	15-23cm	S. f., bluish-grey, middle muddied, on the contact with Pf rusted. W., the plant remains: a lot. Pf below.

t17 30.07.98 APr -AT

Middle flood-plain. Microrelief: hollows and elevations of flood-plain genesis.

A1	0-9cm	S. f. grey, l., h., fr. Sod is absent, L. more dark and more light.
B	9-38cm	L. of greyish-yellow S. and ils of grey h., seldom peated S. M, the plant remains: a little.
CG1	38-66cm	S. yg. M., the plant remains: a little.

List A3-1: continuation

G	66-70cm	Il. of grey mud. W.
CG2	70-89cm	S. yg, sl muddied. W., the plant remains: a little.

t18 30.07.98 AMG

Middle flood-plain.

G1	0-10cm	Sod is absent, l. gleyic muddied horizon with allochthon humus, small spots of rusting. M., the plant remains.
Cg	10-19cm	S. gy with lenses of allochthon P., l. M., the plant remains.
G2	19-33cm	S. dark-grey, dimly l. M, the plant remains.
G3	33-38cm	S. bluish-grey, int. muddied, rusting in ways of old roots. W., the plant remains:. a lot.
G4	38-50cm	S. f., yg, sl muddied. W., the plant remains: a little.
G5	50-53cm	S. f., bluish-grey, int. muddied. W., the plant remains: a little.
Gfe	53-65cm	S. f., grey, spots of rusting. W., the plant remains: a little. Pf below.

t19 30.07.98 APr

Low flood-plain. Microrelief: depressions and elevations with diameter about 4-5 m.

I	0-6cm	S. f. l., greyish-straw and grey h. th. L. (about 2-3mm), sl bended. Fr. W/i.
II	6-10cm	S. f. l., dark h. L. (2-3mm) and L. greyish-straw, more thin, non-h. M. W/i.
III	10-13cm	S. f. l., greyish-straw and grey h. th. L. (about 2-3mm), sl bended. M.
IV	13-20cm	S. f., l., dark h. bg and muddied bluish-grey L. and th. ils of light-grey S. M.
V	20-25cm	S. f. greyish-straw with gb ils. (fragmentarily) the plant remains:, M.
VI	25-28cm	Loam int. muddied, l., dark-grey and grey-brown L., th. ils of light of S. M.
VII	28-35cm	S. f., l., very th. ils of mud. M, the plant remains: a little
VIII	35-40cm	S. f. light-straw-grey, sl l., fragmentarily small ils of mud. M.
IX	40-51cm	Md sanded, grey, sl. l. M, the plant remains.
X	51-61cm	S. straw, sl l. M, W/i.
XI	61-78cm	S. yg, sl l., w, the plant remains: a little Pf below.

V1 08.08.98 PshG

60m to the west from the cliff. Polygons are not expressed, only the first signs of cracks and of axes.

Tv	0-1cm	Lm.
To	1-4cm	Llm d-gb, loose, non-l., sl sanded. M, the rare remains of sedge.
T1	4-10cm	P sl dc, d-gb, l., non-dense, sl muddied, sl sanded, M.
TA	10-12cm	P middle dc, gb, l., int. sanded and muddied, M.
ABg	12-14cm	S. grey, l., int. muddied, h. M., the plant remains.
Bfeg	14-15cm	Rusty strip (S.).
G	15-22cm	Ls bluish-grey, int. muddied, sanded. On the contact with Pf is water. Pf below.

V2 08.08.98

The surface is broken into polygons, there are lakes in most polygons and the rest polygons are wet.

List A3-1: continuation

V2a 08.08.98 PG

A cross-piece between two lakes.

T1	0-13cm	P sl dc, d-gb, moss, the beginning of formation of L. W, interlocked by roots of *Carex* and *Comarum*.
T1	13-34cm	P sl dc, gb, moss-grass, l., sanded (ils of S.). W.

V2b 08.08.98 TG

More high surface between two lakes.

Tv	0-1cm	Lm.
T01	1-5cm	Llm, d-gb, sl sanded, sl. crushed. M.
TA	5-8cm	P grey, l., muddied, h., il. of S. M.
ABg	8-13cm	Ls brownish-grey, int. muddied, l. M., the plant remains: a little.
Bfeg	13-14cm	Rusty l. strip - Ls muddied, M.
G	14-22cm	Ls bluish-grey, muddied. M., the plant remains: a lot.
TG	22-30cm	P bluish-bg, int. muddied, sanded. There is water on the contact with Pf.
		Pf below.

V3a 08.08.98 PG

Quite typical pit: 2 L. of P., 0-13 and 13-31, Pf below.

V3b 08.08.98 TG

On axis.

Tv	0-1cm	Lm.
T01	1-6cm	Llm - P sl dc, gb, sedge-moss, l., sl sanded, fr.
TA	6-8cm	P grey, l., muddied, sanded, h., M.
ABg	8-15cm	Ls grey, muddied, h. M., the plant remains: a little.
Bfeg	15-16cm	Typical
G	16-24cm	Ls blue-grey, muddied. M., the plant remains: a little.
TG	24-27cm	P brown-grey, grass, l., muddied, M.
		Pf below.

V4a 08.08.98 PG

The centre of polygon.

Tv	0-2cm	Lm.
T1	2-13cm	P sl dc d-gb, moss, practically non-l., sl sanded, W.
T2	13-27cm	P middle dc, gb, grass-moss, l., ils of S. and mud. W.
T2[g]	27-40cm	P grey-brown. Muddied and sanded more. W.
		Pf below.

V4b 08.08.98 PshG

Not high axis of polygon.

Tv	0-1cm	Lm
To	1-5cm	Llm, d-gb, sl. sanded. M.
T1	5-10cm	P. sl. dc, sanded. M.
TA	10-14cm	P with S. + humus, bg. M.
ABg	14-20cm	Ls grey, l. M.
Bfeg	20-21cm	Ls rusted.
G	21-28cm	Ls bluish-grey, int. muddied.
		Pf below.

V5 08.08.98 PG

It isn't possible to make any pit, as far as we can judge by bits out of the pit, it is

List A3-1: continuation

d-gb P. Pf is at a depth of 51 cm.

V 6 08.08.98 HG

Polygons are concave. It is the most drained place on the transect V. The pit is almost on the terrace edge.

AoTv	0-2cm	There are blades of grass between Lm.
To	2-4cm	Llm grey-brown-y., non-l., sl sanded, fr.
AT	4-6cm	P with humus and S., bg, fr. The plant remains. Interlocked by living and lifeless roots.
B	6-13cm	S. yg, sl h, but interlocked by living and lifeless roots. Fr, bits of wood in a top.
Ahb1	13-17cm	S. yg, f., more h. and more dark. Fr, living roots: a little.
BC1	17-61cm	S. f., l.: ils of more and less h., bended (cryoturbated). Fr, living roots, bits of wood at a depth of 35 cm.
Ahb2	61-68cm	S. grey. Fr, small bits of wood, living roots.
BC2	68-76cm	S. f., l.: ils of more and less h., bended (cryoturbated). Fr, living roots. Pf below.

V 7 08.08.98 AMPG

Middle flood-plain, depression.

AvTv	0-2cm	Lm, roots of sedge, muddied.
TAg	2-6cm	P grey, grass-moss, int. muddied, but without S., interlocked by living roots.
TG	6-21cm	P grey, grass, int. muddied. Interlocked by living and lifeless roots.
G	21-36cm	Mud bluish-grey, peated. Liquid, is held only by web of roots. Pf below.

V 8 08.08.98 AMPshG

TvAv	0-2cm	Lm - living roots.
AG	2-6cm	Ls (or coarse Loam), grey, int. muddied, but sl peated, compressed. M., interlocked by living roots.
ATG	6-10cm	P L. - grass P grey, very int. muddied, l. M.
BG	10-40cm	Grey l. thick L. Base is S., int. muddied to ls., but there are ils of S. (more coarse, than base, and greyish-yellow) and ils of P. Rusting in ways of some roots.
	40-50cm	ll. of S. yellow-grey with rusting in ways of roots, more coarse, than base of up horizon, practically without mud. W., the plant remains: a little. Fe-Mn concretions.
G	50-58cm	S. bluish-grey, muddied, w, the plant remains.
	58-68cm	ll. of S., yellowish-grey with rusting in ways of roots, more coarse, than base of up horizon, practically without mud. W., the plant remains: a little.
G	68-71cm	S. blue-grey, int. muddied. Pf below.

V 9 08.08.98 AMPshG

Middle flood-plain. Depression before beach-ridge.

AG	0-5cm	S. finest, grey, very int. muddied. M., almost w, interlocked by living roots. The plant remains: a little.
AGT	5-13cm	P bluish-grey. W, interlocked by living roots.

List A3-1: continuation

G 13-63cm Bluish-grey thick layer: S. finest, muddied. W. L. are rather thick, about 8 cm, at a depth of 50 cm il. of S. less muddied, differs by yellowish colour.

Pf below.

V10 08.08.98 APr

Middle flood-plain.

I 0-35cm I. S. thick layer: ils of more muddied and h. S. and less h. gy S. There is il. of very dark h. S. with big quantity of rather large middle dc plant remains on the low boundary. There is almost clear f. S. above it.

II 35-46cm S. middle, yg, M, the plant remains: a little.

III 46-53cm S. finest, d-grey, h., muddied, M, rusting in ways of roots.

IV 53-64cm S. light-yellow-grey with ils of. humus, M., rusting in ways of roots, pointed rust.

V 64-72cm S. yellow-grey, I., M., the plant remains: a little.

VI 72-90cm S. blue-grey, ils and spots of rusting in ways of roots. M., from 85cm W.

Pf below.

V11 11.08.98 APr

Low flood-plain.

I 0-16cm S. I. thick layer: 0-5cm - light-grey sl h; 5-8cm - gy f. non-mud died; 8-10cm -int. muddied h.; 10-16cm -gy f. non-muddied; f.

II 16-25cm P. il., from both sides (on top and from the bottom) limited by sl muddied h. S. P allochthon, re-deposited. M.

III 25-34cm S. f., yellow-grey, small ils of muddied S. M.

IV 34-47cm S. grey, h., ils of mud or int. muddied S. M.

V 47-55cm Woody-P.-S. lens. M., re-deposited.

V 55-81cm S. middle, greyish-y., W., the re-deposited plant remains: a little. There are stones with diameter 3-4cm.

Pf below.

W1 11.08.98 APr

Low flood-plain.

I 0-27cm S. middle I. (more dark grey ils on the back-drop of yellow-grey S.), fr.

I 27-32cm More h and Peated il. - S. Fr.

III 32-41cm S. middle y., M.

IV 41-60cm S. h., M.

V 60-90?cm S. I., grey and gy L. M., from 82cm W.

W2 11.08.98 Apr - AT

Middle flood-plain.

Ah 0-10cm Ls d-grey, int. muddied, I. (th. ils of middle S. M., rather large I. grass remains: a little.

I 10-33cm S. middle, yg, I., ils th. M, living roots: a little.

II 33-87cm Ls muddied, h, I., S. ils: a little. Humidity grows with depth. W. from 83cm.

Pf below.

W3 11.08.98 AMG

Middle part of middle flood-plain.

List A3-1: continuation

AG 0-20cm S. finest grey, l., clear rusting in ways of roots. M., the plant remains, ils of allochthon P.

G 20-66cm l. grey thick layer. Base is muddied f. S., ils are allochthon P (L. of re-deposited plant remains: 1 or less cm of thickness). Thin ils of middle S., rusting in ways of roots is very visible. M., from 50cm W.

W 4 11.08.98 AMG - AMPG

Depression on high flood-plain.
TG 0-20cm P grass, very int. muddied, grey from mod and grey-brown from rust, l. W., interlocked by living roots.
GT 20-35cm Gley muddied blue-grey horizon. P is present, but less, than in horizon above. Living roots less.
Pf below.

W 5 11.08.98 AT

Terrace edge of high flood-plain.
TvAv 0-1cm Lm, web of living roots.
A1 1-6cm S. - light Ls, brownish-grey, h, Fr. Wood was met, that is to say that deposits are alluvial, but humus process adds.
B 6-24cm S. yellow-grey l., ils of more h. and dark S. Fr.
BC 24-83cm There are more h. L., than non-h. L. in this thick. Fr, below almost M.
Pf below.

W 6 15.08.98 AMPG

High flood-plain.
Tv 0-1cm Lm.
T0-1 1-12cm P sl dc, on top non-dc, d-gb, moss, non-l., sl sanded. W.
T2 12-19cm P middle dc, d-gb, l. and compressed, grass-moss, ils of S. W.
GT 19-30cm P int. muddied and sanded, bg because of mud. W., interlocked by living roots.
Gt 30-44cm S. bluish-grey. W, interlocked by living and lifeless roots.
Pf below.

W 7 15.08.98

Fluvial terrace above flood-plain. Polygons mainly are irregular, axes are very rugged, there are many elevations.

W7a 15.08.98 PG

The centre of polygon, part of that is occupied by a lake.
Tv 0-1cm Lm.
T1 1-26cm P sl dc, d-gb, moss, non-l., but only crushed, sl sanded, W.
G 26-30cm Md - P - S. grey, W.
Pf below.

W7b 15.08.98 TG

The corner of axes, rather elevated part.
Tv 0-1cm Lm.
T01 1-5cm P sl dc - lifeless moss, gb, very loose, M.
TA 5-7cm P middle dc, d-gb, int. sanded by light clear sorted sand. l., M.

List A3-1: continuation

Bg 7-35cm Ls grey, l., divided into L., but L. are broken. Compressed, M., the plant remains. There is a strip of rusty at a depth of 25 cm (fragment), but there isn't united one.
Pf below.

W8 11.08.98 PG

Tv 0-2cm Lm.
T1 2-18cm P sl dc, d-gb, moss, sl muddied, sl sanded, l., ils of S. and of mud. W., wood remains.
Pf below.

W9 11.08.98 SG(?)

20m from terrace edge. The surface is covered by sand.
0-1cm S. sprinkling: S. loose, f., straw-grey.
A1 1-18cm Clearly expressed autochthon humus horizon. Ls d-grey, sl l. Fr., living roots. Transition to the lower horizon is gradual, but clear, boundary regular.

BC 18-63cm S. straw-light-grey, l., th. ils of humus and of re-deposited P. Fr.
C 63-91cm Ls d-grey, l., more h and peated, sl muddied, M.
Pf below.

Abbreviations used for the soil description

dc.	:	decomposed
d-gb	:	dark-greyish-brown
fr.	:	fresh
gb	:	greyish-brown
h	:	humused
il, ils	:	interlayer(s)
int.	:	intensively
L.	:	layers
l.	:	layered
Llm	:	lifeless mosses
Lm	:	living mosses
Ls	:	loamy sand
M.	:	moist
P.	:	peat
Pf	:	permafrost
Pf below	:	there is permafrost below
S.	:	sand
sl.	:	slightly
W.	:	wet
W/i	:	without includings
yg	:	yellowish-grey

List A3-2: Preliminary total list of plant species from the Samoylovskii Island, Lena delta total taxa 280; vascular plants 173 taxa; Lichens 53 taxa; Bryophytes 54 taxa.

Vascular plants

Aconogonon tripterocarpum (A. Gray) Hara
Agrostis vinealis Schreb.
Alopecurus alpinus Smith
Antennaria friesiana (Trautv.) Ekman
Antennaria lanata (Hook.) Greene
Antennaria villifera Boriss. = Antennaria lanata
Arabis petraea (L.) Lam. ssp. umbrosa (Turcz.) Tolm. = Cardaminopsis petraea
Arctagrostis arundinacea (Trin.) Beal
Arctophila fulva (Trin.) Anderss.
Arctous alpina (L.) Niedenzu
Arctous erythrocarpa Small
Armeria maritima (Mill.) Willd.
Artemisia furcata Bieb.
Artemisia tilesii Ledeb.
Astragalus alpinus L.
Astragalus umbellatus Bunge
Bistorta elliptica (Willd. ex Spreng.) Kom.
Bistorta major S. F. Gray
Bistorta vivipara (L.) S. F. Gray
Calamagrostis holmii Lange
Calamagrostis lapponica (Wahlenb.) C. Hartm.
Calamagrostis neglecta (Ehrh.) Gaertn., Mey. & Schreb.
Caltha arctica R. Br.
Caltha arctica ssp. caespitosa (Schipcz.) A. Khokhr. = Caltha caespitosa Schipcz.
Caltha caespitosa Schipcz.
Cardamine digitata Richards.
Cardaminopsis petraea (L.) Hitt.
Carex aquatilis Wahlenb. ssp. stans (Drej.) Hult. = Carex concolor R. Br.
Carex bigelowii Torr. ex Schwein. ssp. lugens (H. T. Holm) Egor = Carex lugens H. T. Holm
Carex concolor R. Br.
???Carex hordorhiza - not in Czerepanov
Carex lugens H. T. Holm
Carex maritima Gunn.
Carex rariflora (Wahlenb.) Smith
Carex stans Drej = Carex concolor R. Br.
Cassiope tetragona (L.) D. Don
Castilleja pallida (L.) Spreng.
Cerastium beeringianum Cham. & Schlecht.
Cerastium jenisejense Hult.
Chrysosplenium alternifolium L. ssp. tetrandrum (Lund ex Malmgr.) Hult. = Chrysosplenium tetrandrum (Lund ex Malmgr.) Th. Fries
Chrysosplenium tetrandrum (Lund ex Malmgr.) Th. Fries
Coeloglossum viride (L.) C. Hartm.
Comarum palustre L.
Delphinium brachycentrum Ledeb.
Deschampsia borealis (Trautv.) Roshev.
Deschampsia cespitosa (L.) Beauv. ssp. borealis (Trautv.) A. & D. Love = Deschampsia borealis (Trautv.) Roshev.
Descurainia sophioides (Fisch. ex Hook.) O. E. Schulz
Draba alpina L.
Draba pilosa DC.
Dryas octopetala L.
Dryas octopetala L. ssp. punctata (Juz.) Hult. = Dryas punctata Juz.

List A3-2: continuation

Dryas punctata Juz.
Dupontia psilosantha Rupr.
Endocellion sibiricum (J. F. Gmel.) Toman
Eriophorum polystachion L.
Eriophorum scheuchzeri Hoppe
Eriophorum vaginatum L.
Equisetum arvense L.
Equisetum arvense L. ssp. boreale (Bong.) Tolm. = Equisetum arvense L.
Equisetum scirpoides Michx.
Equisetum variegatum Schleich. ex Web. & Mohr
Festuca richardsonii Hook.
Festuca rubra L.
Festuca rubra L. ssp. arctica(Hack.) Govor. = Festuca richardsonii Hook.
Gastrolychnis apetala (L.) Tolm. & Kozhanczikov
Gastrolychnis involucrata (Cham. & Schlecht.) A. & D. Love
Gentiana sp.!
Hedysarum arcticum B. Fedtsch.
Hedysarum hedysaroides (L.) Schinz & Thell. ssp. arcticum (B. Fedtsch.) P. W. Ball = Hedysarum arcticum B. Fedtsch.
"Hieracium pauciflorum" - not in Cherepanov
Hippuris vulgaris L.
Juncus trifidus L.
Kobresia myosuroides (Vill.) Fiori
Koeleria asiatica Domin
Lagotis glauca Gaertn. ssp. minor (Willd.) Schischk. = Lagotis minor (Willd.) Standl.
Lagotis minor (Willd.) Standl.
Lloydia serotina (L.) Reichenb.
Luzula confusa Lindeb.
Luzula multiflora (Ehrh.) Lej.
Luzula nivalis (Laest.) Spreng.
Luzula tundricola Gorodk. ex V. Vassil.
Melandrium affine (J. Vahl ex Fries) J. Vahl = Gastrolychnis involucrata (Cham. & Schlecht.) A. & D. Love
Melandrium apetalum (L.) Fenzl = Gastrolychnis apetala (L.) Tolm. & Kozhanczikov
Minuartia arctica (Stev. ex Ser.) Graebn.
Minuartia rubella (Wahlenb.) Hiern
Minuartia stricta (Sw.) Hiern
Minuartia verna (L.) Hiern ssp. glacialis (Fenzl) Kuvajev = Minuartia rubella (Wahlenb.) Hiern
Myosotis asiatica (Vestergren) Schischk. & Serg.
Nardosmia frigida (L.) Hook. = Petasites frigidus
Nardosmia gmelinii Turcz. ex DC. = Endocellion sibiricum (J. F. Gmel.) Toman
Neuroloma nudicaule (L.) DC. = Achoriphragma nudicaule (L.) Sojak
Orthilia obtusata (Turcz.) Hara
Orthilia secunda (L.) House ssp. obtusata (Turcz.) House = Orthilia obtusata (Turcz.) Hara
Oxytropis arctica auct. = Oxytropis karga Saposhn. ex Polozh.
Oxytropis karga Saposhn. ex Polozh.
Oxytropis middendorffii Trautv.
Oxytropis nigrescens (Pall.) Fisch.
Oxytropis vassilczenkoi Jurtz.
Papaver angustifolium Tolm.
Papaver lapponicum (Tolm.) Nordh.
Papaver lapponicum ssp. orientale Tolm.
Papaver paucistamium Tolm. & Petrovsky
Papaver radicatum Rottb.
Papaver sp.

List A3-2: continuation

Parnassia palustris L.
Pedicularis albolabiata (Hult.) Ju. Kozhevn.
Pedicularis capitata Adams
Pedicularis sceptrum-carolinum L. - ? on which site
Pedicularis gymnostachya (Trautv.) A. Khokhr.
Pedicularis hirsuta L.
Pedicularis interioroides (Hult.) A. Khokhr.
Pedicularis lanata Cham. & Schlecht.
Pedicularis langsdorfii Fisch. ex Stev.
Pedicularis oederi Vahl
Pedicularis parviflora Smith ssp. pennellii (Hult.) Hult. - Pedicularis pennellii Hult.
Pedicularis pennellii Hult.
Pedicularis sudetica Willd.
Pedicularis sudetica Willd. ssp. albolabiata Hult. = Pedicularis albolabiata (Hult.) Ju. Kozhevn.
Pedicularis sudetica Willd. ssp. interioroides Hult. = Pedicularis interioroides (Hult.) A. Khokhr.
Pedicularis sudetica Willd. ssp. jacutica Ju. Kozhevn. = Pedicularis gymnostachya (Trautv.) A. Khokhr.
Pedicularis verticillata L.
Pedicularis villosa Ledeb. ex Spreng.
Petasites frigidus (L.) Fries
Poa arctica R. Br.
Poa paucispicula Scribn. & Merr.
Poa pratensis L.
"Poa pratensis L. vivipara = Poa pratense ssp. bulbosa" - ? not in Cherepanov
Poa sublanata Reverd.
Poa vivipara (L.) Willd.
Polemonium boreale Adams
Polygonum bistorta L. = Bistorta major S. F. Gray
Polygonum bistorta L. ssp. ellipticum (Willd. & Spreng.) Petrovsky = Bistorta elliptica (Willd. ex Spreng.) Kom.
Polygonum tripterocarpum A. Gray = Aconogonon tripterocarpum (A. Gray) Hara
Polygonum viviparum L. = Bistorta vivipara (L.) S. F. Gray
Populus suaveolens Fisch.
Pyrola rotundifolia L. ???
Ranunculus gmelinii DC.
Ranunculus lapponicus L.
Rumex acetosa L.
Rumex graminifolius Lamb.
Salix glauca L.
Salix glauca x Salix fuscescens Anderss. - ??? hybride
Salix hastata L.
Salix krylovii E. Wolf
Salix lanata L.
Salix nummularia Anderss.
Salix polaris Wahlenb.
Salix pulchra Cham.
Salix reptans Rupr.
Salix reticulata L.
Sanguisorba officinalis L.
Saussurea tilesii (Ledeb.) Ledeb.
Saxifraga bronchialis L. ssp. funstonii (Small) Hult. = Saxifraga funstonii (Small) Fedde
Saxifraga cernua L.
Saxifraga funstonii (Small) Fedde
Saxifraga hieracifolia Waldst. & Kit.
Saxifraga hirculus L.

List A3-2: continuation

Saxifraga nelsoniana D. Don
Stellaria ciliatosepala Trautv.
Stellaria crassifolia Ehrh.
Stellaria monantha Hult.
Tanacetum bipinnatum (L.) Sch. Bip.
Tofieldia coccinea Richards.
Tofieldia pusilla (Michx.) Pers.
Tofieldia sp.
"Trisetum arvense - boreale" ? - not in Cherepanov
Trisetum litorale (Rupr. ex Roshev.) A. Khokhr.
Trisetum sibiricum Rupr. (Sic!)
Trisetum sibiricum Rupr. ssp. litorale Rupr. ex Roshev. = Trisetum litorale (Rupr. ex Roshev.) A. Khokhr.
Vaccinium uliginosum L. ssp. microphyllum Lange
Vaccinium uliginosum L.
Vaccinium vitis-idaea L.
Valeriana capitata Pall. ex Link

Bryophytes

Abietinella abietina (Hedw.) Fleish.
Aulacomnium acuminatum (Lindb. & H. Arnell.) Kindb.
Aulacomnium palustre (Hedw.) Schwaegr.
Aulacomnium turgidum (Wahlenb.) Schwaegr.
Brachythecium sp.
Bryum pseudotriquetrum (Hedw.) Gaertn. & al.
Bryum sp.
Calliergon cordifolium (Hedw.) Kindb.
Calliergon giganteum (Schimp.) Kindb.
Calliergon megalophyllum Mikut.
Calliergon sarmentosum = Warnstorfia sarmentosa
Calliergon stramineum (Brid.) Kindb.
Campylium stellatum (Hedw.) C.. Jens.
Campylium sp.
Ceratodon purpureus (Hedw.) Brid.
Cinclidium arcticumB. S. G.
Cinclidium latifolium Lindb.
Cinclidium subrotundum Lindb.
Cirriphyllum cirrosum (Schwaegr.) Grout
Climacium dendroides (Hedw.) Web. & Mohr
Dicranum angustum Lindb.
Distichium capillaceum (Hedw.) B. S. G.
Ditrichum flexicaule (Schwaegr.) Hampe
Drepanocladus exannulatus = Warnstorfia exannulata
Drepanocladus intermedius = Limprichtia cossoni
Drepanocladus revolvens = Limprichtia revolvens
Drepanocladus uncinatus = Sanionia uncinata
Drepanocladus vernicosus = Hamatocaulis vernicosus
Entodon concinnus (De Not.) Paris
Eurhynchium pulchellum (Hedw.) Jenn.
Hamatocaulis vernicosus (Mitt.) Hedenaes
Hylocomium splendens (Hedw.) B. S. G.
Hylocomium splendens var. alaskanum = Hylocomium splendens var. obtusifolium
Hylocomium splendens var. obtusifolium (Geh.) Paris
Limprichtia cossoni (Schimp.) Anderson et al.

List A3-2: continuation

Limprichtia revolvens (Sw.) Loeske
Lophozia ruthiana (Hepaticae)
Meesia longiseta Hedw.
Meesia triquetra (Richter) Aongstr.
Meesia uliginosa Hedw.
Oncophorus wahlenbergii Brid.
Orthothecium chryseon (Schwaegr. ex Schult.) Schimp.
Paludella squarrosa (Hedw.) Brid.
Philonotis tomentella Molendo
Pleurozium schreberi (Brid.) Mitt.
Pohlia cruda (Hedw.) Lindb.
Pohlia nutans (Hedw.) Lindb.
Polytrichastrum alpinum (Hedw.) G. L. Sm.
Polytrichum alpinum = Polytrichastrum alpinum
Polytrichum juniperinum Hedw.
Racomitrium lanuginosum (Hedw.) Brid.
Rhytidium rugosum (Hedw.) Kindb.
Sanionia uncinata (Hedw.) Loeske
Scorpidium scorpioides (Hedw.) Limpr.
Sphagnum squarrosum Crome
Syntrichia ruralis (Hedw.) Web. & Mohr
Thuidium abietinum = Abietinella abietina
Thuidium philibertii Limpr.
Timmia austriaca Hedw. var. arctica (Lindb.) H. Arnell
Tomentypnum nitens (Hedw.) Loeske
Tortella fragilis (Hook. & Wilson) Limpr.
Tortula ruralis = Syntrichia ruralis
Warnstorfia exannulata (B. S. G.) Loeske
Warnstorfia sarmentosa (Wahlenb.) Hedenaes

Lichens

Alectoria nigricans (Ach.) Nyl.
Alectoria ochroleuca (Hoffm.)
A. Massal.Biatora sp.Bryocaulon divergens (Ach.) Karnefelt Bryoria sp.
Cetraria islandica (L.) Ach.
Cetraria laevigata Rass.
Cetrariella fastigiata (Nyl.) Karnefelt & A. Thell
Cladonia acuminata (Ach.) Norrl.
Cladonia amaurocraea (Florke) Schaer.
Cladonia chlorophaea (Somerf.) Spreng.
Cladonia coccifera (L.) Willd.
"Cladonia crispata/degenerans"
Cladonia ecmocyna Leight.
Cladonia furcata (Huds.) Schrad.
Cladonia gracilis (L.) Willd.
Cladonia pocillum (Ach.) Grognot
Cladonia pyxidata (L.) Hoffm.
Cladonia "squamosa"
Cladonia stricta (Nyl.) Nyl.
Dactylina arctica (Hook.) Nyl.
Dactylina ramulosa (Hook.) Tuck.
Flavocetraria cucullata (Bellardi) Karnefelt & A. Thell
Flavocetraria nivalis (L.) Karnefelt & A. Thell
Hypogymnia "physodes/ subobscura"

List A3-2: continuation

Lecanora epibryon (Ach.) Ach.
Leptogium saturninum (Dicks.) Nyl.
Leptogium "tenuissimum"
Leptogium sp.
Lobaria linita (Ach.) Rabenh.
Masonhalea richardsonii (Hook.) Karnefelt
Megaspora verrucosa (Ach.) Hafellner & V. Wirth
Nephroma expallidum (Nyl.) Nyl.
Ochrolechia sp.
Pannaria pezizoides (Weber) Trevis.
"Pannaria praetermissa"
Peltigera aphthosa (L.) Willd.
Peltigera canina (L.) Willd.
Peltigera didactyla (With.) J. R. Laundon
Peltigera malacea (Ach.) Funck
Peltigera rufescens (Weiss) Humb.
Peltigera scabrosa Th. Fr.
Peltigera venosa(L.) Hoffm.
Peltigera sp. (glossy)
Pertusaria bryontha (Ach.) Nyl.
Physconia muscigena (Ach.) Poelt
Psoroma hypnorum (Vahl) Gray
Ramalina sp. (Ter)
Solorina sp.
Stereocaulon alpinum Laurer
Sticta arctica Degel.
Thamnolia vermicularis (Sw.) Schaer.
Thamnolia vermicularis var. subuliformis (Ehrh.) Schaer.

- Vascular Plants det. Ju. P. Kozhevnikov, from the Komarov Botanical Institute, St.-Petersburg
  (Nomenclature: S. K. Czerepanov. 1995. Plantae vasculares Rossicae et civitatum collimitanearum. S. Petropolis. 990 p.)
- Bryophytes det. Irina V. Czernyadjeva, from the Komarov Botanical Institute, St.-Petersburg (Nomenclature: Afonina, O. M. & I. V. Czernyadjeva. 1995. Mosses of the Russian Arctic: check-list and bibliography. Arctoa. 5: 99-142.)
- Lichens det. by Mikhail P. Zhurbenko from the Komarov Botanical Institute, St.-Petersburg,

4 Modern Sedimentation and Environmental History of the Lena Delta

4.1 Introduction

(V. Rachold, M. N. Grigoryev and M. Antonow)

The Lena Delta is the main connection between interfering continental and marine processes within the Laptev Sea. Large amounts of material are supplied to the delta by the Lena River. After modification due to internal delta dynamics parts of the material are delivered to the Laptev Sea.

Accumulation and erosion in the coastal zone are of major importance for the modern and ancient sediment budget of the Laptev Sea. The amount of sediments transport by the Siberian rivers are relatively well quantified. However, the portion of sediments that is deposited in the river deltas, mainly in the Lena Delta, and, therefore, never actually reaches the Laptev Sea, is not known. Furthermore the amount of material delivered to the Laptev through the erosion of ice-rich coast lines has not been accurately quantified. Figure 4-1 summarizes these factors controlling the sediment budget of the Laptev Sea.

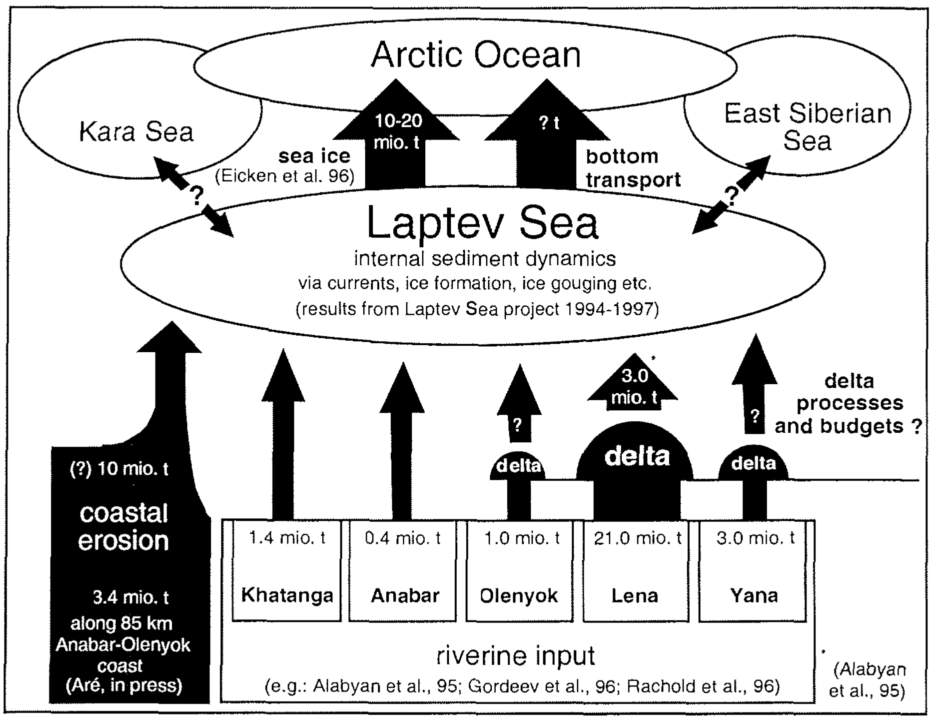


Figure 4-1: The sediment budget of the Laptev Sea.

The sedimentation history of the Lena Delta, its importance as a fossil accumulation area as well as the processes that control the lateral extension are poorly understood. While the eastern part of the Lena Delta is assumed to be an actual „active“ delta the western part consists of pre-Holocene sandy deposits and Ice Complexes (see Chapter 4.3.1).

The Lena Delta is a large Arctic delta and the conditions are very different from that of delta regions in lower latitudes. Figure 4-2 illustrates the dominant role of the Lena Delta in the Laptev Sea and summarizes the factors that influence its formation.

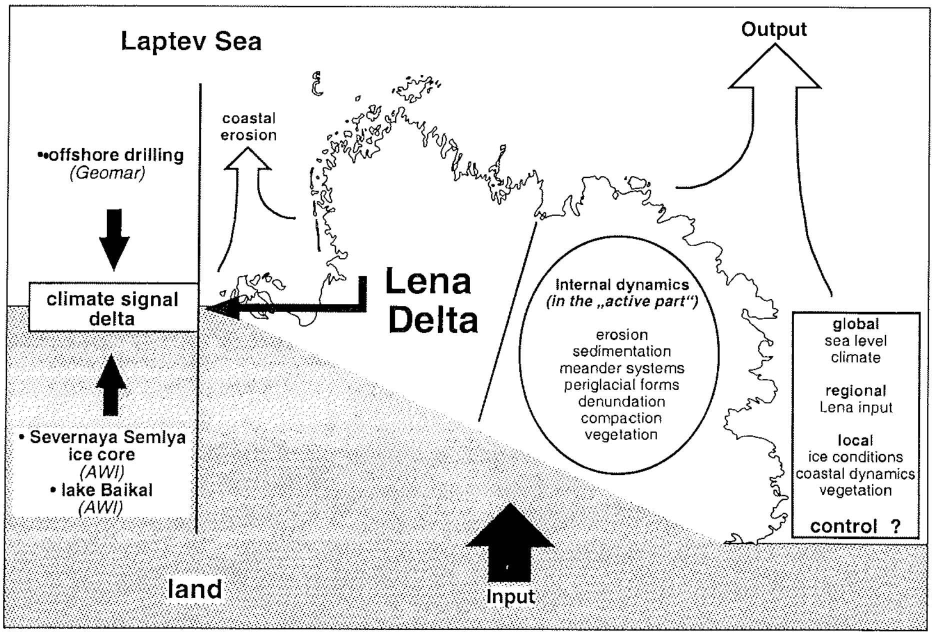


Figure 4-2: The central role of the Lena Delta for land-ocean interactions in the Laptev Sea.

The scientific objectives of our working group are:

- The reconstruction of the sedimentation history of the Lena Delta;
- To understand the influence of global, regional and local climate variability on the formation of the Lena Delta;
- To identify modern processes that control the accumulation and the erosion within the delta;
- To quantify seasonal variation in the material balance of the Lena Delta;
- To quantify the modern and ancient sediment budget of the Laptev Sea.

4.2 Modern Sedimentation in the Lena Delta

Introduction

(M. Antonow)

Nearly half a year the Siberian shelf and river areas are monotonously ice-covered due to the Arctic winter conditions. Vertical as well as lateral processes of particle transport and water movement seem to be at a low level during a complete ice coverage. Sediment material becomes incorporated into sea ice by the ice formation (freeze-up) in autumn.

The onset of the river break-up (and later the melting of sea ice, respectively) allows a rapid increase of particle transport by river run-off to the Arctic ocean and to the Laptev Sea, respectively. Sediment dynamics will be intensified and very variable within a short year-by-year "new" Arctic spring. Then, during the summer period the regular and very dynamic hydrological system of the Lena Delta establishes as well as the vegetation growth.

The permafrost conditions in the ground remain, but the mobility of particles of the surface (including the active layer) and a large scale of transport mechanisms leads to a remarkable internal dynamics of the Lena Delta region.

The role of Siberian´s largest delta in the context of mass budget and transfer at the sea-land transition is poorly understood. Some results of former investigations do not fit to the puzzle of a regular delta as well as a relicish one.

The main scientific goals are:

- characterization of the sediment dynamics in the Laptev Sea delta-shelf system,
- assessment of the contrast between accumulation and erosion of the Lena Delta,
- the registration of the present small scale surficial circulation pattern and the bottom current regime as well as water level studies,
- the estimation of the sediment transport of the main channels of the Lena Delta.

4.2.1 Recent mechanisms of particle transport in the Lena Delta

(M. Antonow, V. Rachold, O. Golovanov, V. Kunitsky and M. Grigoryev)

Moving of sediments by suspension and bedload transport

Field measurements document the suspension transport in the Lena Delta main channels during the 1998 expedition (see following chapter 4.2.2). The ratio of sediment accumulation and erosion is controlled by the particle transport depending on grain size and current velocity. Deposition of sand is generally due to the cessation of an episode of bedload transport, to accumulation during steady flow with excess sediment supply, or to deposition from suspension from powerful, decelerating currents. After deposition from suspension, sand may continue to move as bedload before it finally comes to rest.

Small-scale structures on the modern surface

Sediment structures of the (sub)aquatic environment reflect a variety of transport processes and they are the clearest indicators of the types and strengths of currents that move sediments.

During the expedition a latter of small-scale structures on the modern surface have been recognized such as erosion forms (obstacle scours, longitudinal ridges and furrows, rill marks) and the lateral migration of river channels that document the equilibrium of erosion and sedimentation.

Geomorphological changes

Field observations show an intensive internal dynamics of the Lena Delta. Sediment gravity flows and debris flows (mud flows, grain flows) common occur seasonally when thawing leads to relief unstabilities. This thermoabrasion induces downhill mass movements and supplies the former permafrost fixed particles to lateral distribution. The coastal erosion at the land/sea boundary to the southern Laptev sea proceeds at some sites even with decameters per year. Wind driven currents support the bank destruction by coastal resuspension and winning of sediments.

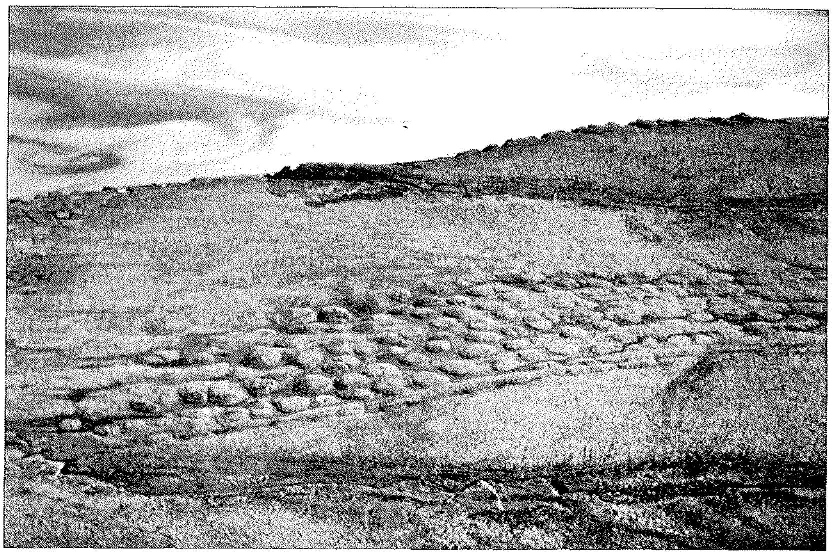
The lateral migration of river channels and the erosive action of the Spring meltwaters lead to a continous change of river geometry and flooding areas (sand banks, drainage channels) in the very active part of the Lena Delta. Of course, the land-water distribution within the delta is triggered by saisonal changes of the water level each year (see following chapter 4.2.3).

A survey of reeper positions gives evidence of the high variability mentioned above. A relocation of reeper signs established in the 40-60s of this century was partially succesfull during the 1998 field period. Only Bykovskaya channel reepers located on hard rock substrate at higher elevations in the region near Stolb island could be found, whereas reepers installed at the soft-rocky ground of fluvial teracces were not discovered due to erosion/destruction. A set of reeper signs at the coast of Bykovsky peninsula was surveyed and reestablished at new landward sites.

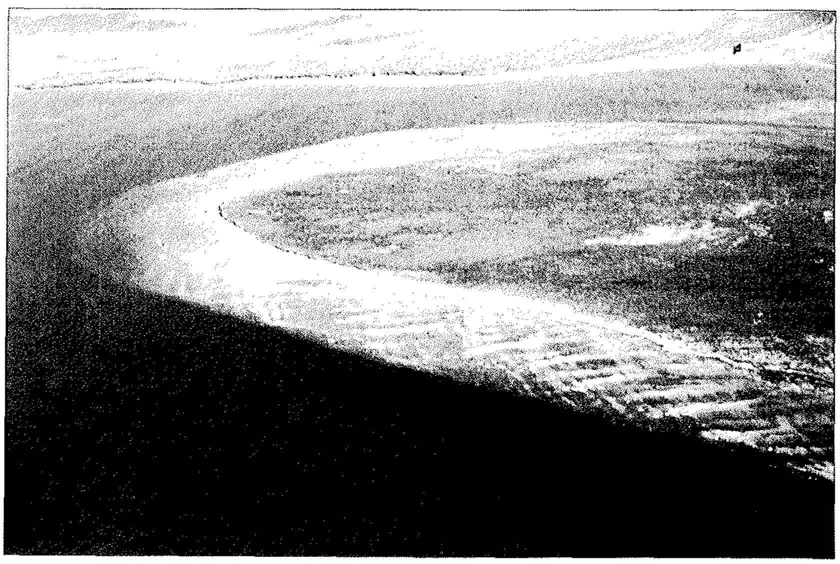
Eolian processes and transport by river ice

During the short Arctic summer conditions the main transporting medium are the Lena river waters. But also wind strongly affects the particle transport (even grain-size to coarse sand fraction) of the delta region. Eolian activity strongly stresses the vegetation or has wiped it out. Many deflational plains were observed mainly in the Arga region. Despite the existance of large meteorological data sets and climatic models the magnitude of eolian mass transport from the Siberian hinterland via the Lena Delta towards the Laptev Sea is poorly understood.

Year-by-year enormous mass movement by ice occur during the river break-up. Due to the melting flood Lena river ice is stacked and moved. As a result the river bed is eroded in its shallower parts and gravel rims built up along the river bank. Field observations were obtained during the TRANSDRIFT IV expedition 1996 (International Biological Station Lena-Nordensheld, Bykovskaya channel).

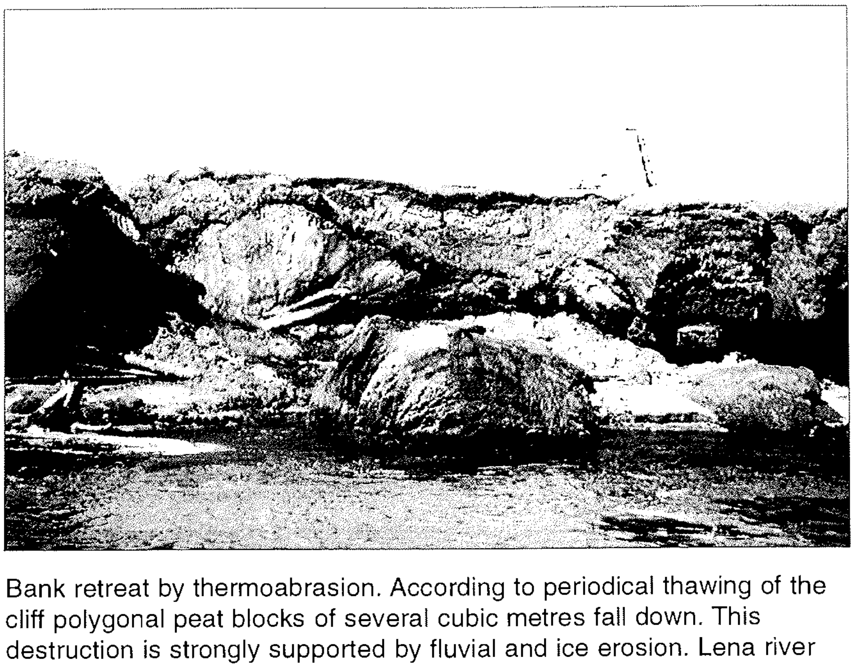


Land-sea boundary at Bykovsky peninsula near the Mammoth pingo. The denudative relief is formed by intensive thermokarst, thermoerosion, thermoabrasion, and thermodenudation. Remarkable particle transport by near shore suspension currents at subaqueous shallows and sand bars (see upper part).



Interference pattern of currents under steady flow conditions at low water stage cause sediment resuspension and mass transfer around delta islands and sandbanks. Note the net particle transport to the right (islands region north of Bolshaya Trofimovskaya channel).

River bank destruction at Sardakh-Aryta insula (Sardakhskaya channel). Note the subparallel extension cracks due to draining of the sedimentary body (medium to coarse sand).
The inner stability of the alluvial terraces is given by its frozen ground.
This scenery is omnipresent in the seasonally flooded areas of the Lena terrace I all over the delta.



Bank retreat by thermoabrasion. According to periodical thawing of the cliff polygonal peat blocks of several cubic metres fall down. This destruction is strongly supported by fluvial and ice erosion. Lena river terrace I of Samoylov Island, centre of Lena delta.

Especially the area of Arga island is exposed to strong westerly and north-westerly winds (see wind driven sandy streaks). In the case of lack of vegetation only local iron/hydroxide cementation crusts covering the surface prevent the eolian mass export by deflation of large delta plains.

Recent small-scale structures reflect the endless seeming variety of deltaic river beds and flood plains. Asymmetrical current ripples with sinous to lingoid crests on a river bed near Sardakh-Aryta insula. They result from unidirectional steady, but low-energy currents. Relic of massive bedded sand from a former high level water stage to the right.

4.2.2 In-situ conditions of the water column in August 1998

(M. Antonow, O. Golovanov and V. Rachold)

The MUM-equipment

A specialized probe was designed in order to measure the properties of the water column. Besides temperature and conductivity these include the amount of supended matter in the water column and direction and velocity of currents. This probe (MUM = "Modulares Umweltmess-System" built by ADM Elektronik GmbH, Warnau, Germany) combines up to 11 individual sensor units in one housing. Energy is supplied by 9 LR20 1.5V batteries in a water and pressure resistant housing together with the electronic CPU (central processing unit). The CPU carries 3 memory chips: one 64 kb program EPROM, one 8 kb RAM for individual batch commands and one 248 kb RAM as a static data store for up to 124,000 data. The CPU allows individual programming of measuring intervals and an additional variety of sub- and burst cycles within one measuring interval. The MUM is armed with a V4A steel cage to shield it from damage.

The following sensors are fixed to the CPU housing: a piezoresistive pressure-gauge, a Pt 100 temperature sensor, a 7 pin conductivity cell, an AANDERAA INSTRUMENTS compass, and a piezoelectrical ultrasonic oscillator device for measurements of the current velocity in X, Y and Z directions. The following individual sensors can be placed where ever it is necessary (i.e. on the CPU housing, the cage or even the cable depending on the length of the data cable): one calorimetric thermistor for current velocity measurements, and an optical backscatter system (OBS) to measure the relative amount of suspended matter in the water column. These devices are connected with the CPU via data cables and plugs. After each deployment data are recovered via a laptop computer. The data are given in ASCII format (integer values between 0 and 60,000) and need to be parsed, calibrated and statistical treated before any further interpretation.

Field work

MUM-measurements were performed at 17 stations in the main channels of the Lena river as well as offshore the delta north of Bykovskaya Peninsula. The investigated sites reached water depths of 16 m, mainly 6 to 10 m. Additionally, water samples (2 litres) were taken and filtered to obtain the particulate suspended matter of surface water and of near-bottom water (use of 0.45µm HVLP filters by MILLIPORE®). Preliminary results can be summerized as follows:

A) nearly homogenous water column inside the main channels with temperature of about 10 to 12 °C and salinity of about 0.2 per mill.
B) strong currents and remarkable contents of particulate suspended matter of surfical and near bottom water column (Figure 4-3).

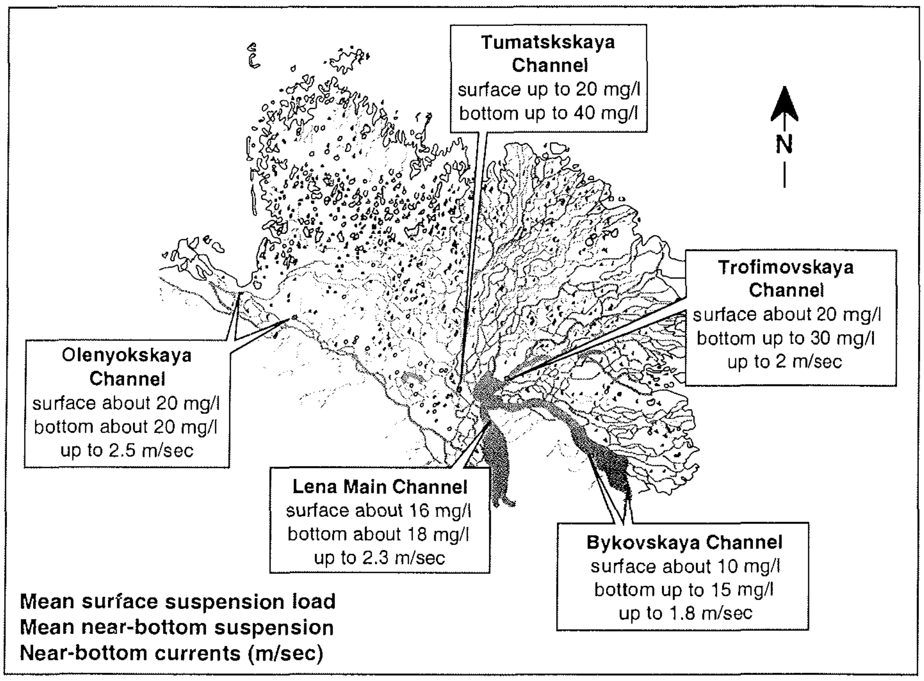


Figure 4-3: This sketch generalizes in-situ conditions during August 1998 and the results of suspension (mg/l of surface and near bottom waters) and bottom currents (m/sec). The variations are mainly caused by the river morphology and the ground substrate.

Delta-Shelf transect

MUM-measurements and water sampling from sites inside the Bykovskaya channel across the river mouth towards the Southern Laptev Sea have been performed to record hydrographic gradients of the Land-Sea transition zone.

At the 1998 late Arctic summer the usual hypopycnic conditions were determined (see diagrams, next page). Note the continous decrease of temperature and the seawards changes of salinity of surface as well as bottom waters. Oftenly, near-bottom currents cause amounts of suspended terrigenous matter in the lowermost water layer. In combination to this, the contrast of fresh and oceanic water masses leads to a significant increase of suspension load at the hydrographic frontiers.

For the characterization of sediment dynamics of the Laptev Sea shelf system a combination of important oceanographic, hydrooptical parameters, and quantitative filter suspension data (all determined during the TRANSDRIFT V expedition with RV Polarstern in 1998) will be neccessary in order to evaluate the hydrographic conditions during this field period.

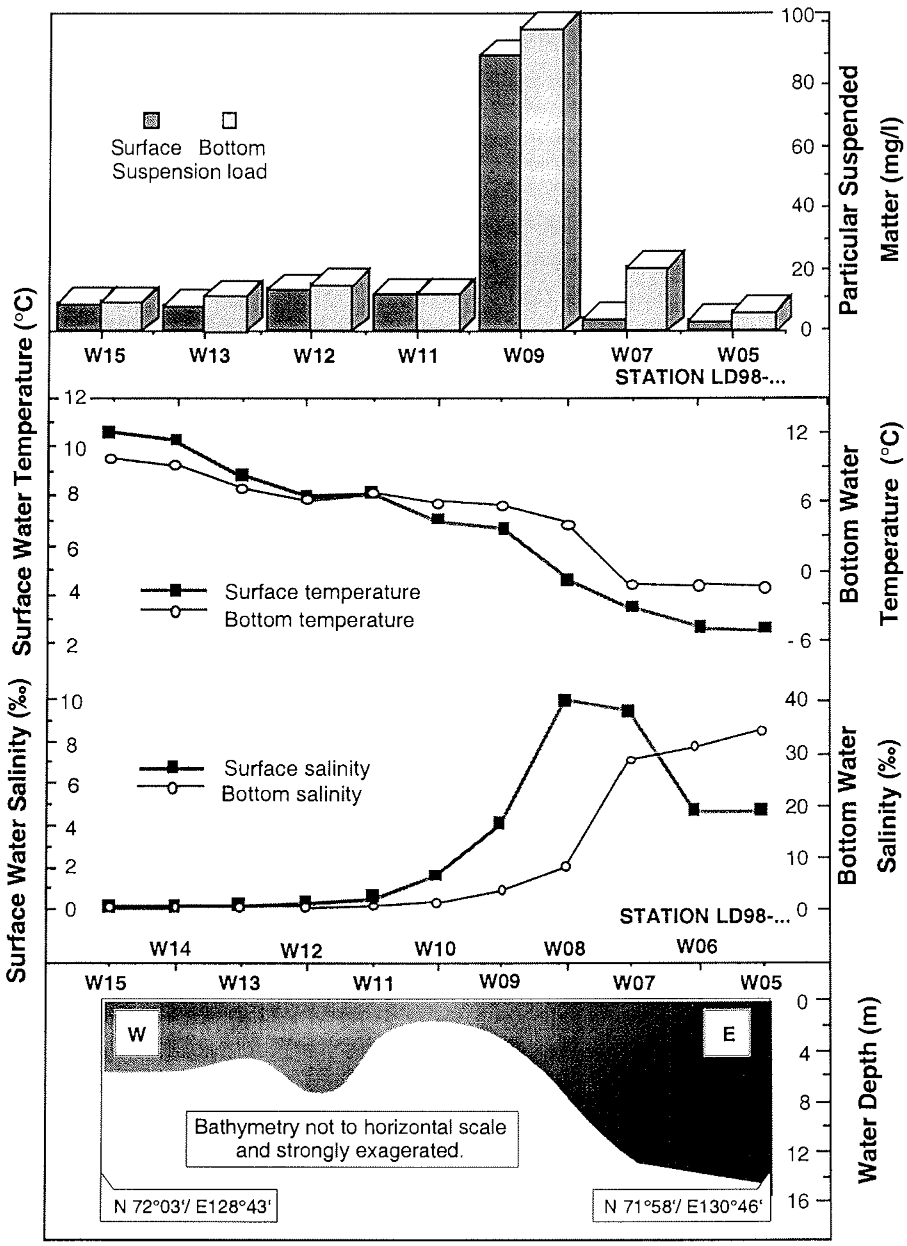


Figure 4-4: Hydrographic transect North off Bykovsky Peninsula. The measurements were carried out 08/11/1998 and 08/12/1998). Transect length approximate 70 km. For exact station locations of LD98 W05...LD98 W15 see station list (Table A4-1, appendix).

4.2.3 Saisonal changes of water level in the delta region

(M. Antonow, M.N. Grigoryev, V. Rachold and E. Reimnitz)

The Lena River drainages large parts of the Siberian continent and discharges hugh amounts of particles, dissolved matter and fresh water, respectively. The manner in which the Lena River dumps the Spring meltwaters into the ice-covered Laptev Sea probably depends on the water depths in the very mouths of individual distributary channels and their ice-coverage. The Lena River can rise as much as 10 m above its normal level during break-up in June. A rising water level might cause a rise in mean sea level in the coastal waters. Tide gauges placed along several transect from inside the Lena River channels monitor water- and ice-level changes during several seasons of the year. This long-term monitoring (up to three years) as well as the planned river break-up field study seem to be important for some findings about Land/Sea interactions of this Russian Arctic environment.

Material and Methods

The measurements were carried out using MINILOG-equipment by VEMCO Ltd. (Nova Scotia, Canada). The MINILOG-TD is a miniature data logger that records temperature and pressure (water depth) at a user programmed time interval. This microprocessor controlled data logger stores data to internal Electrically Erasable Programmable Read Only Memory (EEPROM). The temperature and depth readings are taken with an 8 bit Analog to Digital (A/D) converter. In general, the sample periods ranges from 1 second to 6 hours which give a deployment time from at least 2 hours to 5 years. The data can be offloaded and plotted using the MINILOG-PC Interface and an IBM/PC/AT computer. MINILOG-reader/software Version 1.13 was available. Each individual Minilog-TDR sensor (-5 to 35°C and 0.2 degree resolution with a 17 m full scale depth range) housed in a waterproof PVC cylinder (21 mm diameter by 94 mm length) has a 5 year lithium battery (good for about 1000 deployments) which can be replaced at the factory. Data retention (maximal 8128 Temperature and 8128 Depth readings) exists up to 20 years.

Sensor Deployments

A set of 9 individual sensors was moored along selected main channel transects in order to get an idea of the hydrographic changes during the year-around investigation. For the mooring positions and the in-situ water depths of the sensors see Table 4-1, Figure 4-5. The TDR-sensors were moored at the river bottom and fixed by a 50 to 70 m long rope and ground weights. In the future they will be relocated by significant landmarks and GPS position. The sample interval was 2 to 3 hours, which allowed a deployment time maximum of about three years. The minimum deployment depth of about 6 m should prevend an erosive destruction of the moored sensors by river ice during the break-up in Spring. A recovery of these sensors is planned in the year of 2000.

Table 4-1: TDR-Minilog deployments during the LENA 98 expedition.

Sensor No.	Mooring Position, Geographic Location	Deployment Depth	Deployment Date
LD98M01	72°22.104'N/126°47.461'E, South of Samoylov Island	6.5 m	07/25/1998
LD98M02	72°52.941'N/123°14.580'E, Olenyokskaya Channel	11.0 m	08/07/1998
LD98M03	72°46.316'N/124°00.107'E, Olenyokskaya Channel	9.0 m	08/08/1998
LD98M04	72°27.328'N/126°21.793'E, Tumatskaya Channel	9.5 m	08/09/1998
LD98M05	72°02.770'N/128°43.141'E, Bykovskaya Channel	6.7 m	08/12/1998
LD98M06	72°12.021'N/128°03.734'E, Bykovskaya Channel, IBS LN	8.0 m	08/12/1998
LD98M07	72°31.826'N/126°49.858'E, Trofimovskaya Channel	7.5 m	08/17/1998
LD98M08	Lena main channel at Tit-Ary	13.5 m	08/18/1998
LD98M09	72°24.589'N/127°13.011'E, Bykovskaya Channel	10.0 m	08/20/1998

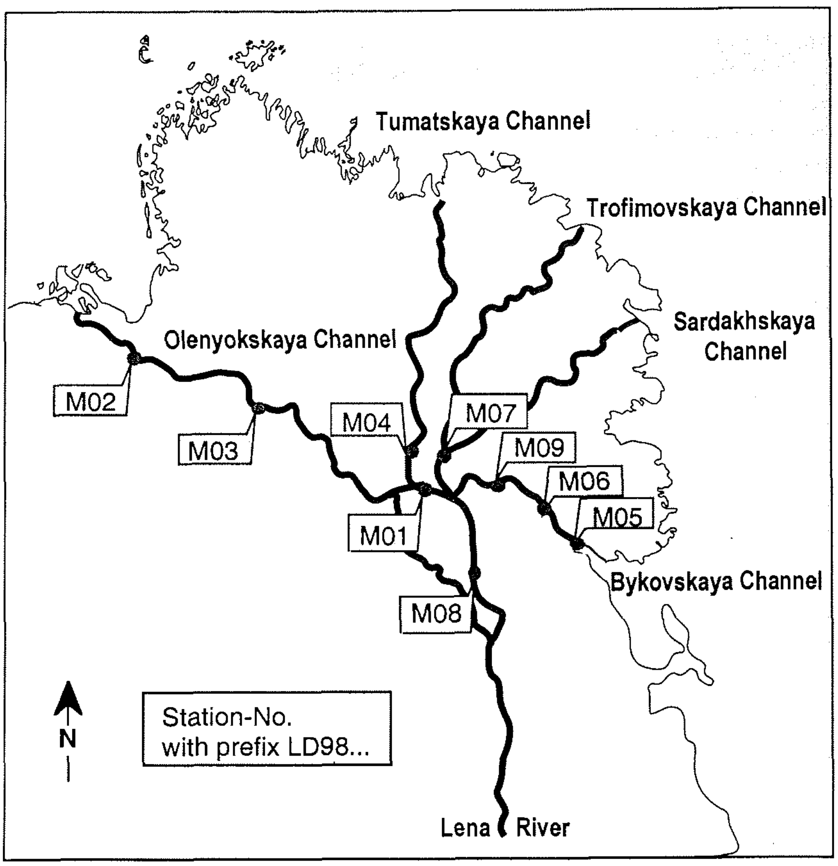


Figure 4-5: Geographic positions of moored MINILOG-sensors.

4.3 Sedimentation and environmental history of the Lena Delta

(G. Schwamborn, W. Schneider, M. Grigoryev, V. Rachold and M. Antonow)

4.3.1 Introduction

The Lena river draining to the Siberian Arctic is considered to be the main sediment source for the Laptev Sea. Nevertheless, the Lena Delta - occupying an area of 28.000 km^2 - is a poorly studied and complicated region of Land-Ocean-Interactions in the Arctic. There are many unsolved questions concerning the environmental and sedimentation history, geomorphology, genesis of deposits, permafrost distribution and climatic variability in that area.

The first studies of the Lena Delta environment were carried out at the end of the last century by the geologists Bunge (1895) and Toll (1897). In the beginning of the 20th century several Russian researchers investigated geology, geomorphology, climate, biology and permafrost conditions in the Lena Delta (Vise, 1926; Evgenov, 1929; Gusev, 1936; Ryazantsev, 1937; Nikolaev, 1938; Obruchev, 1938; Sax, 1948). More detailed studies concentrating on hydrology, relief, cryogenic processes, permafrost conditions, ground ice, vegetation and climate started in the second half of the current century (Antonow, 1960; Gusev, 1960; Strelkov, 1965; Grigoryev, 1966; Klyuev, 1966; Lungershausen, 1966). During the last two decades more complex expeditions with a duration of 1-4 years have been carried out. During this period Russian and foreign scientists studied geomorphology, cryolithology, hydrology, paleogeography, tectonics, permafrost conditions, Quaternary geology and greenhouse gas fluxes (Are, 1980; Galabala, 1987; Kunitsky, 1989; Korotaev, 1991; Grigoryev, 1993; Fukuda, 1993; Alabyan et al., 1995; Rachold et al., 1996).

Figure 4-6 summarizes the current state of knowledge of the age of the Lena Delta.

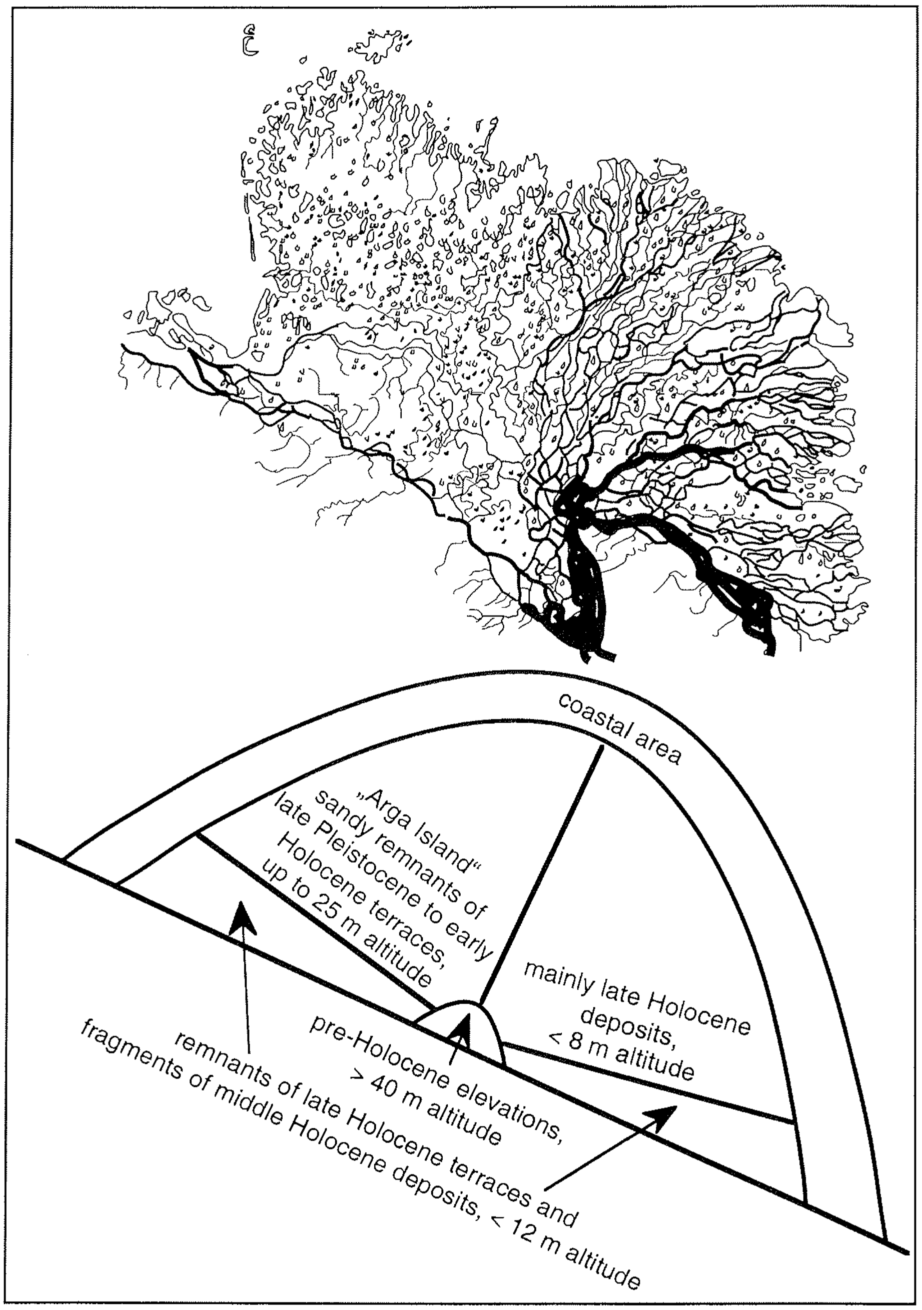


Figure 4-6: Current state of knowledge of the age of the Lena Delta (modified form Grigoryev, 1993).

Despite these investigation a number of questions concerning the history of the Lena Delta are still unsolved:

- Some scientists believe that Pleistocene glaciers covered a significant part of the Lena Delta. However, direct glacial traces in this area could not be identified until now.
- The age of ground ice and sediments of the second (sand lowland) and third (Ice Complex) terraces fn the Lena Delta are specified by some scientists as Middle Pleistocene and Late Pleistocene. Nevertheless, the exact ages of ice-wedges and ice- sheets in deposits of the second and third terraces are not established yet. The age correlation between the second sandy terrace and third (Ice Complex) terrace is still discussed. The genesis of the sandy deposits of the second terrace is unknown.
- The majority of the scientists believe that the Ice Complex was formed by fluvial and polygenetic processes, but also other processes are discussed.
- The genesis, age and morphology of the large and deep lakes on the second terrace (Arga Island) is unknown.
- It was supposed that continuous taliks exist under these lake depressions but new data indicate that permafrost can be found under these lakes.
- The age of the three floodplain levels and the first above the floodplain level is determined as Holocene, but the exact ages of the borders between the floodplain levels are unknown.
- There are open questions concerning the contour of the Lena Delta coastline in the Early and Middle Holocene and the role of neotectonics for Lena Delta contour formation.
- The rates of shore retreat or advance in the Lena Delta during Holocene and today have never been quantified.

4.3.2 Samples and methods

To identify sedimentary and permafrost structures within the Lena Delta sampling on land was done by shallow coring, through natural exposures, and by applying ground penetrating radar completed by theodolite surveys. On lake water studies of sedimentary sequences have been carried out doing shallow seismic in high resolution mode and by taking shallow gravity cores. Age determinations of the deposits will be based on radiocarbon and OSL datings. This included a special sampling dedicated to OSL specimens to meet the laboratory´s requirements (see chapter 5-6).

Due to size of the Lena Delta sampling had to focus on some key locations which are indicated in Figure 4-7.

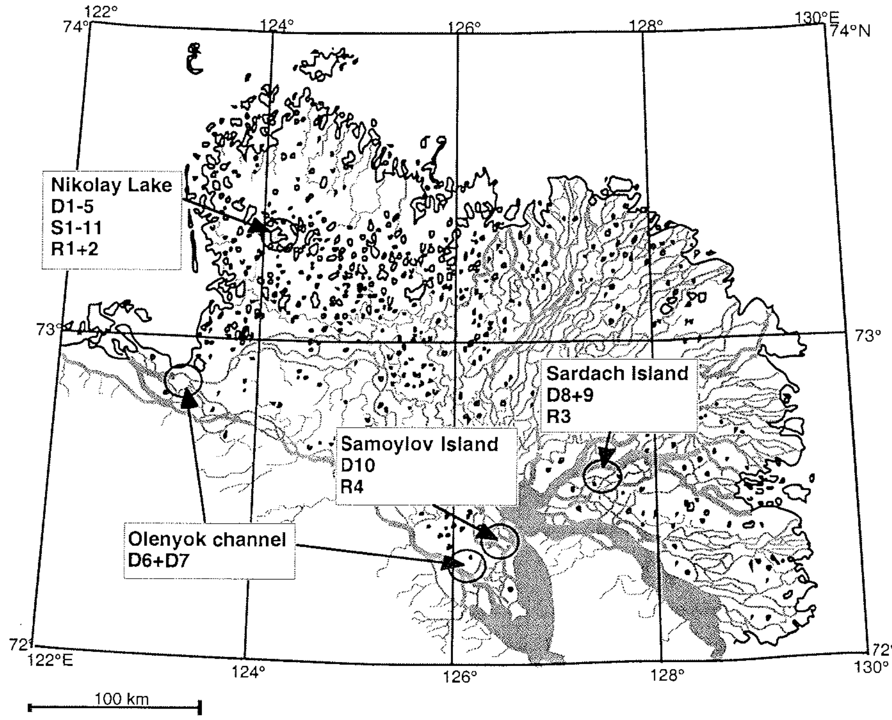


Figure 4-7: Map of Lena Delta showing sites of sediment sampling (D 1-10), shallow seismic (S 1-11) and radar surveys (R 1-4).

Lena Delta sediment samples collected during field work in summer 1998 reveal physical and hydrochemical properties of the processes controlling the late Quaternary conditions of accumulation and deposition. Mineralogical sampling supports provenance studies for presumed Pre-Holocene locations.

After freeze-drying of the samples laboratory work concentrates on grain-size analysis and magnetic susceptibility for indicating changes in lithology and comparing different data sets. Geochemical characterizations of sedimentary profiles are provided by measurements of TC-, N-, S-concentrations on pulverized specimens by IR-absorption (C and S) and temperature conductivity (N) using a Leco element analyzer and TOC-concentrations using an Eltra analyzer (METALYT CS 100/1000 S).

Geochemical permafrost properties as an expression of paleohydrology are examined by measuring water soluble cation and anion concentrations. In addition, pH values and electrical conductivity are determined. Laboratory work is performed using water extractions from dried and pulverized sediment samples. The samples are filtered through 0.45 μm cellulose acetate filters. Firstly pH and electrical conductivity (μS/cm) are recorded by a WTW instrument. Major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Sr^{+}, Ba^{+}, Al^{3+}, Ti^{+}, Fe^{2+}, Mn^{2+}) will be analyzed by ICP-OES (Optima 3000XL from Perkin Elmer) from the volume of 25 ml of a a-priori de-mineralized water. An IC-2001 ionchromatograph (Eppendorf company) will be used to determine the main anions (NO_2^-, NO_3^-, SO_4^{2-}, Cl^-, Br^-, F^-, PO_4^{3-}) using the same water extractions. The chromatograph applies the suppression method (suppression column BT-S-AG-P) by separating the EKXAN-CO_3 / EKXAN-HCO_3 eluent from the injected sample liquid. Concentrations are calculated then from the chromatogram using the "WINPEAK" software (EPPENDORF).

Geophysical methods of sub-bottom profiling were applied in two ways:

(1) A RAMAC impulse radar system was used to explore the potential for ground-penetrating radar (GPR) in the permafrost domain of the Lena Delta. As a reasonable way for mapping near subsurface structures GPR responds to changes in physical properties of the ground e.g. the dielectric contrast between different materials. However, it does not reveal the actual composition of the soil or rock. Therefore, additional information from bore holes is needed. The electric/dielectric properties of ground materials are partly determined by their dry characteristics, i.e. grain-size distribution, porosity and mineralogical composition. In dependence on these dry properties the amount of liquid water, ice, and air present in the ground greatly influences its electric/dielectric properties and thus reflection from interfaces and attenuation of the transmitted signal. The sediment depth then can be calculated by using the following approximated values for ε_r (relative permittivity) and the resulting velocities (μ/ms) for media relevant in the Lena Delta permafrost domain (the larger value given for velocity applies for unsaturated media):

Medium	ε_r	**Velocity (m/μs)**
fresh water	81	33
permafrost	4-8	106-150
ice	3-4	150-173

The 25 and 100 MHz radar signals were able to penetrate the permafrost down to 30 m at maximum distinguishing main sediment types, i.e. fluvial deposits and periglacial features like ice wedges and ice layers. Drilling results served to determine the geologic composition. Figure 4-8 illustrates the operation of the RAMAC GPR in the field.

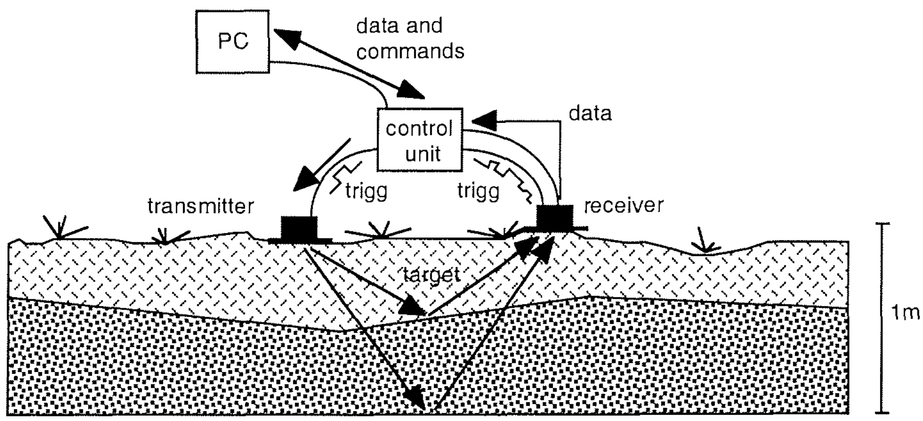


Figure 4-8: Schematic diagram of the connected system. The transmitter and receiver antennas are connected to the control unit through optical fibres. The scheme shows a subsurface horizon reflecting parts of the transmitted energy back to the receiver.

(2) A sediment echo sounder (GeoChirp 6100A from Geoacoustics, UK) was applied for seismic surveying of lake sediments in the western Lena Delta. The high-frequency pulse source operated in the high resolution mode with a frequency range of 1.5 to 11.5 kHz which reveals a theoretical resolution of 7.5 cm. The seismic reflections were automatically processed during the cruises and presented analogously on an on-line plotter.

Based on the seismic data it was possible to characterize the geometry of basin fills and changes in lake sedimentation as well as to identify the permafrost boundary around talik zones. As a good approximation the sediment depth from Chirp records has been calculated by assuming average sonic velocities of 1420 m/s for the water column, 2000 m/s for unconsolidated lacustrine sediments, and 2200 m/s for permafrost. For further reading about the GeoChip system the reader is referred to Niessen et al. (1997).

4.3.3 Field work and preliminary results Arga Island

Arga Island is a geomorphological term for the western part of the Lena Delta bordered by the Olenyokskaya channel in the south and the Tumatskaya channel in the east. The sandy deposits are believed to be of Pre-Holocene fluvial origin, but no age determinations are available yet and a mineralogical comparison with Holocene Lena deposits is missing.

Nikolay lake area was chosen as a representative place to study the sedimentary surface and the subsurface structures. With more than 25 m water depth Nikolay lake is the deepest lake on Arga Island. Its origin is still unknown. For the combination of survey methods on land and on Nikolay lake water see Figure 4-9.

Nikolay lake is the largest steady water body in the Lena Delta. From west to east the lake is ca. 8 km wide and from north to south ca. 6 km long. It consists of five sub-basins. Approximately 70% of the lake area has a water depth of less than 2 m. Shallow seismic studies therefore concentrated on the deeper parts of the lake where the water depth can be more than 20 m (LD98-S1-11). Radar sounding was performed to extend the subsurface profiling to the shallow part of the lake and to the land (LD98-R2). Upper lake sediments have been collected by a gravity corer at 4 sites (LD98-D2-5). At the shore line sediments have been sampled by drilling into the permafrost after digging and washing out an outcrop (LD98-D1).

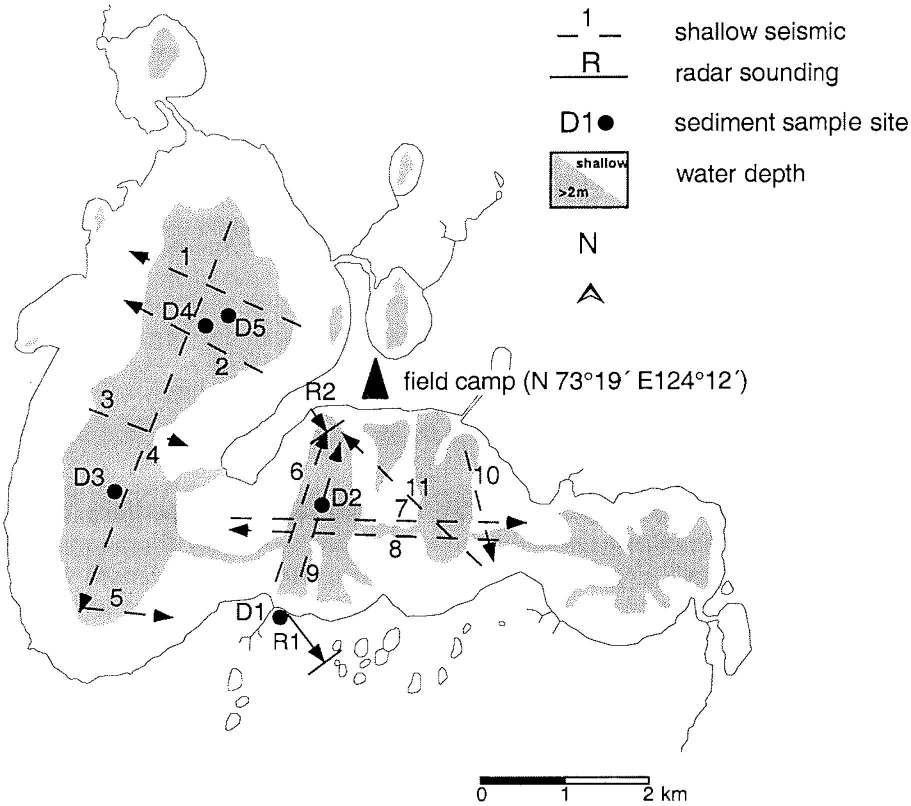


Figure 4-9: Map of Nikolay lake with locations of shallow seismic (S1-11), radar profiling (R1+2), and sediment sample sites (permafrost D1 and lake sediments D2-D5).

The late Quaternary sediments of Arga Island as found in Nikolay lake area are horizontally bedded in mm- to cm-scale and macroscopically appear to be well sorted in the fine sand fraction. They show no further remarkable sediment structures which indicates fluvial deposition under upper flow regime. The sediments are bound by lens-shaped texture ice and contain complex systems of massive ice veins belonging to ice wedges (Figure 4-10). The average ice content is around 20% of the total weight.

Sediment samples were collected for OSL datings and to determine grain-size distribution and mineralogical composition of the deposits. Ice samples are to be investigated for their isotopic oxygen and hydrogen ratios illuminating a

Holocene or Pleistocene genesis of the ice wedges. AMS ^{14}C datings are in progress for the upper lake sediments to complement data for the reconstruction of the local sedimentary history. The lake sediments have shown a probably autochthon existence of algae in Nikolay lake. They are accompanied by typical fresh water diatom assemblages and sponges of the high Arctic according to their occurrence in smear slide data.

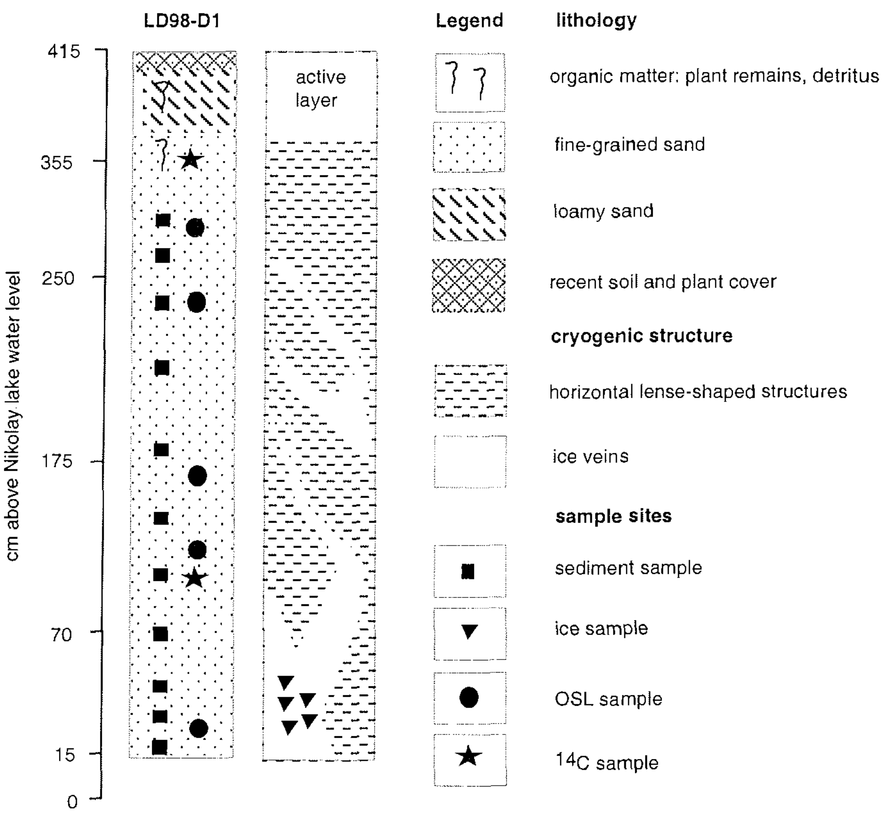


Figure 4-10: Sediment sample site LD98-D1 at Nikolay lake (location N 73°18.978′, E 124°12.877′), profile of Quaternary Lena sediments with cryogenic textures.

Shallow seismic sound penetration is observed down to a depth of 120 m at maximum at 25 m water depth. The bathymetric information of the 11 high resolution profiles confirms a straight downward movement of the lake ground in the central parts of the basins as it is already indicated on aerial photography. The irregular shape of the lake floor often shows one or two morphological steps framed by steep slopes before reaching the deepest base of the basin. The sediment fill covering the different subaqueous levels varies in thickness and at some places shows slumping structures of several meters in scale. The reflector geometry of profile 1 demonstrates higher sedimentation rates for the deeper parts. This suggests that sediment focusing effects into the central basin are important for the deposition of the upper most seismic unit (Figure 4-11).

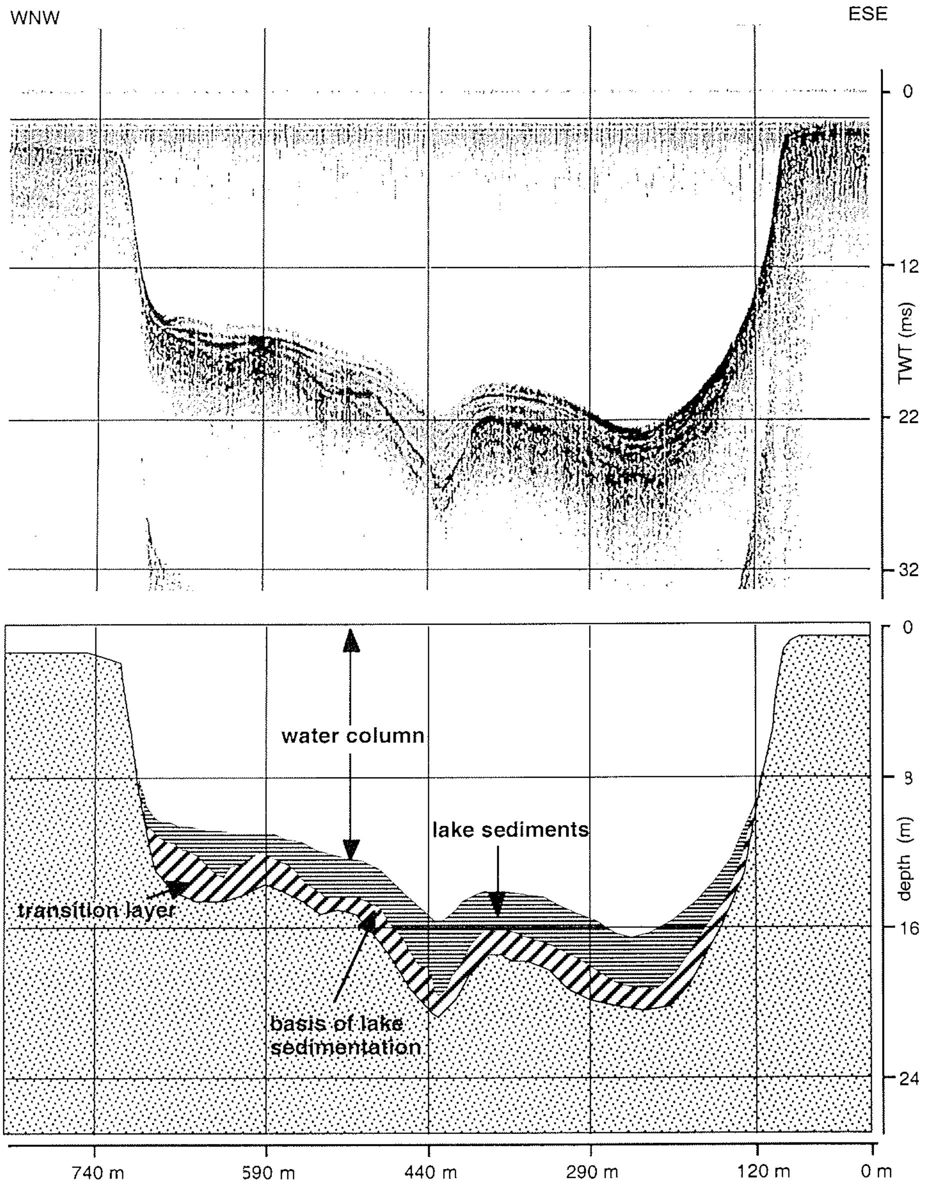


Figure 4-11: Shallow seismic profile no. 1, Nikolay lake. Top: on-line profile. Bottom: interpretation of the seismic section.

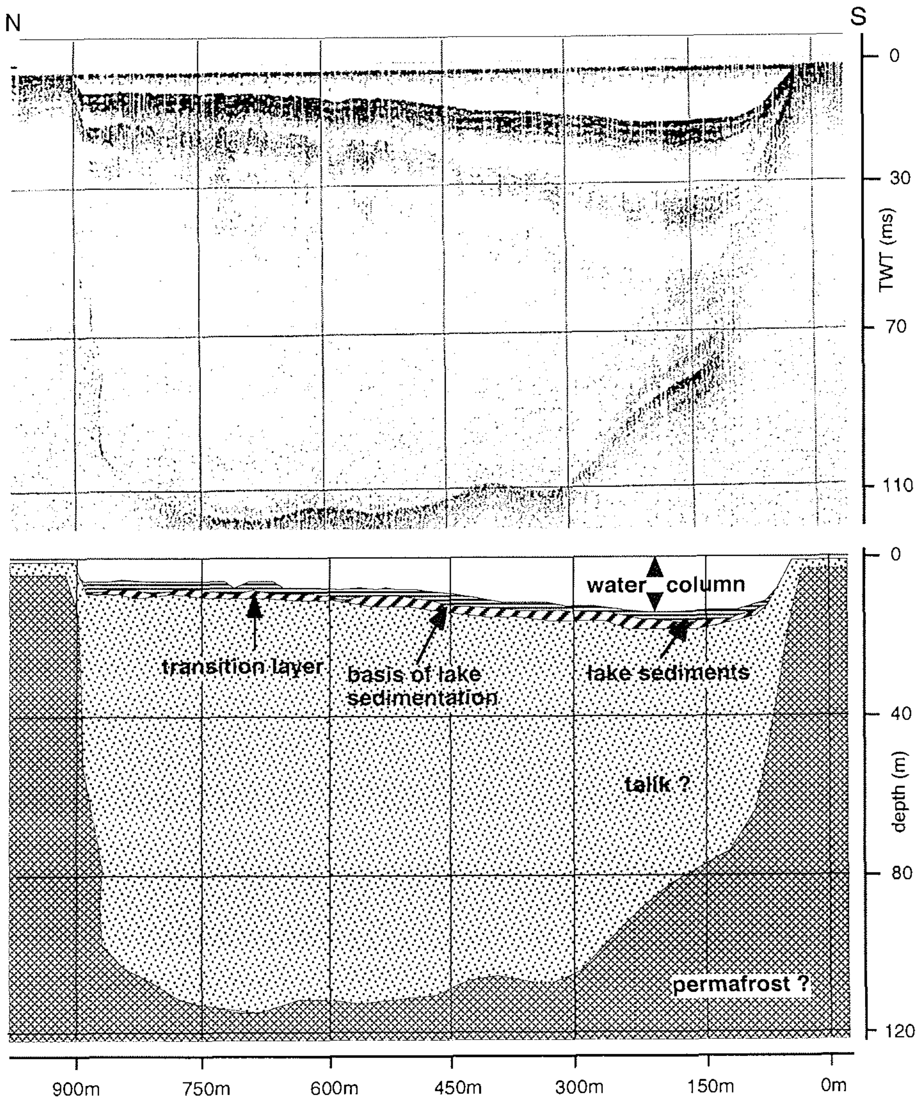


Figure 4-12: Shallow seismic profile no. 6, Nikolay lake. Top: on-line profile. Bottom: interpretation of the seismic section.

As it appears on the left side of the profile minor local troughs seem to be filled preferably as well. This is an evidence of predominantly gravitational sediment movements rather than suspensional ones. Actually, there is a lack of namebable in- or outflows around Nikolay lake which would support suspensional sediment transport. Changing backscatter in the lateral extension of the reflection horizons may come up due to variations of organic matter in the sediments. They mainly consist of silty sand as seen from the gravity cores. The origin of the transition layer marked in the interpretation sketch must remain obscure as long as no deeper sediment core is available. A paleosoil having different composition than the underlying sediments is just as probable as a thawing and re-freezing of the original substrate which could have changed the density of the former ground surface and thus caused the seismic reflections. The same considerations can be applied for a transition layer identified in seismic profile 6 (Figure 4-12).

The seismic propagation of profile 6 transmitting through a less deep water body reaches down to 120 m and reveals a basic reflector at about 110 m. From several shallow onshore cores recovered near Nikolay lake it is known that the subsurface is mainly composed of structureless frozen sand. Since no layered seismic reflections show a change in sedimentation the curved seismic boundary is assumed to be created by the talik / permafrost boundary. To the left and to the right of the presumed talik seismic penetration seems to be prevented by the permafrost table. Hence deeper sediment structures remain unobserved. Subsidence of the talik material might have destroyed bedding structures as well.

Summarizing the seismic profiles show lake sedimentation which is mainly promoted by gravitational movements. Thawing of shore banks causes destabilized slopes and results in downward movements of sediments, maybe initiated by seismic events. The spreading of the shore line has probably merged several small thermokarst lakes together forming Nikolay lake as the largest lake of the region.

At the shore of Nikolay lake various radar profiles were recorded in order to extend subsurface studies on land. The antennas used during the field studies had nominal or center frequencies of 25 and 100 MHz. Antenna separation was 1 m (100 MHz) and 4 m (25 MHz) and the spacing used between the traces was 20, 40, 70, or 100 cm. Not all of the survey results are shown here; rather, one example is displayed to represent certain features (Figure 4-13).

Radar profile 1 lengthens shallow seismic profile 6 southward and shows sedimentary elements of the onshore subsurface. It has been recorded with the 25 MHz antenna and trace intervals of 100 cm. Starting on top, a well developed horizon occurs below the surface. This is considered to be the thaw/freeze interface at an average depth of 60 cm, which produces several returns caused by reverberation of the electromagnetic energy within the active layer. When slightly undulating the uppermost reflection pattern marks the tops of ice wedges, for example at 10, 38, 150, 230 m along the section. Below the active layer in the permafrost deposits the chart appears to be broken and displaced into single, detached segments. These segments may represent disrupted and sheared frozen ground possibly resulting from ice wedge growth. In the middle area of the chart on the left side some diagonal layers show up and on the right side a few horizontal ones can be observed. They are believed to represent original fluvial layering not affected from ice wedge growth. Both structures are underlain by one prominent, horizontal reflector which shows a single reflection. Only a small amount of energy has penetrated below this horizon due the reflection and/or absorbency of radar waves in this layer. Even after enhanced re-processing of the radar data, only minor subsurface details are recognizable indicating a similar sedimentary environment like in the upper area.

The major radar signal at a depth of approximately 60 m is interpreted as caused by a sedimentary event like a sedimentation hiatus or an erosional surface.

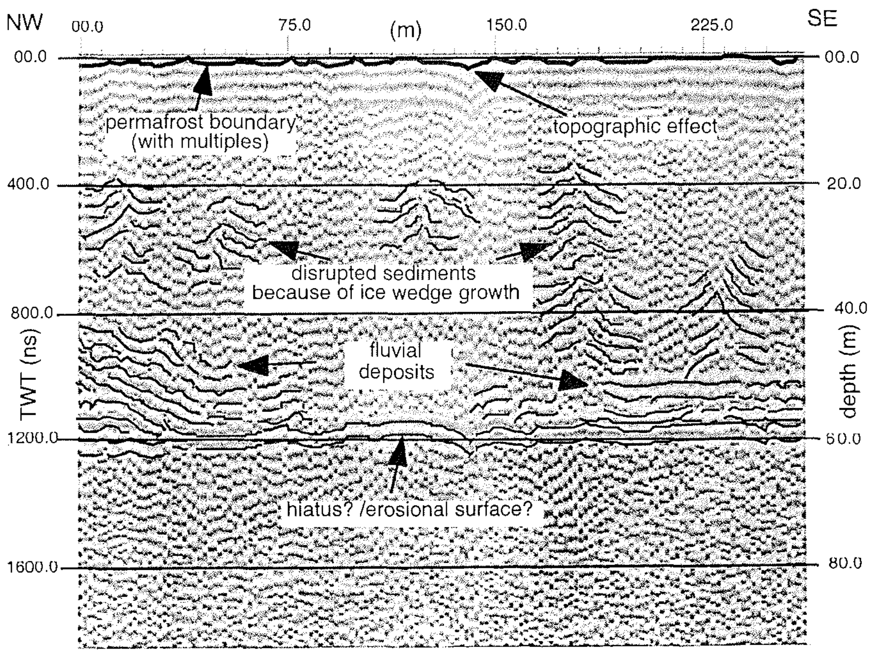


Figure 4-13: Interpreted 25-MHz radar profile R1 southwards of Nikolay lake (without topographic correction).

4.3.4 Field work and preliminary results at Olenyok channel

Two sedimentary profiles LD98-D6 and D7 at Olenyok channel (Figure 4-7) have been sampled to complement sediment studies of LD98-D1. The studies focus on grain-size distributions, mineralogical composition, and will provide further age determinations based on both radiocarbon and OSL.

Since the surface of the outcrop was thawed no drilling was needed and sampling was carried out with respect to outcrop conditions and sedimentary units (Figure 4-14). Predominantly wavy bedding seem to reflect sedimentation under fluvial conditions although plant remains form some root horizons. The laboratory work is in progress and escpecially SEM investigations are expected to clarify the origin of the sediments, i.e. fluvial or glaciomarine or eolian as some authors propose.

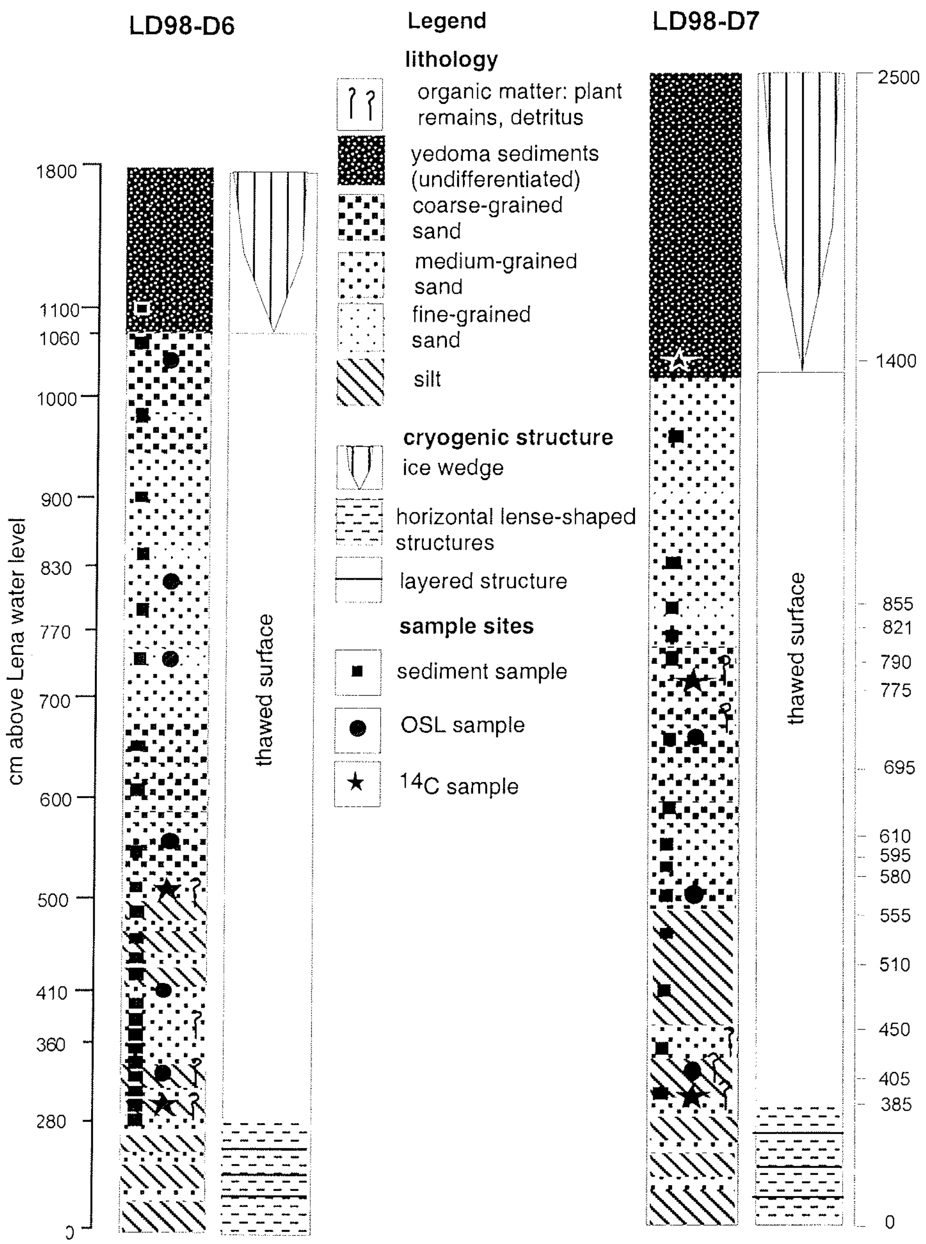


Figure 4-14: Sediment sample sites LD98-D6 (N 72°52.812′, E 123°12.500′) and LD98-D7 (N 72°20.711′, E 126°18.748′) at Olenyok channel , profiles of Quaternary Lena sediments with cryogenic textures.

4.3.5 Field work and preliminary results at Sardakh channel

For investigating the Holocene stage of the Lena River a representative site has been chosen near Sardakh Island. Geologic and geophysical survey comprised sediment drilling down to 925 cm and radar profiling (Figure 4-15).

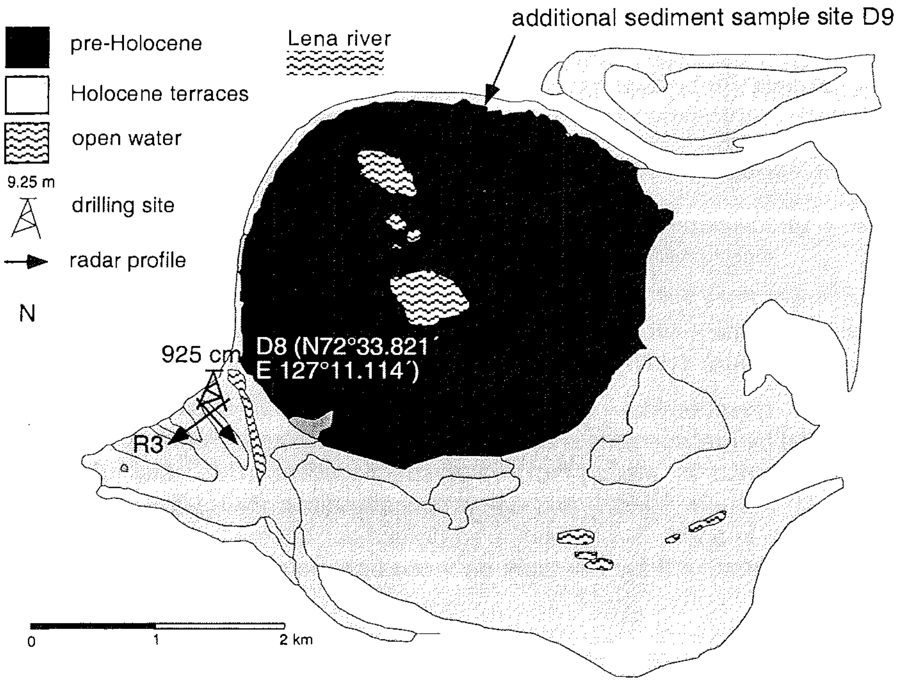


Figure 4-15: Map of Sardakh Island showing locations of radar profiling R 3 and sediment drilling site D8 with coordinates.

The location is characterized by the formation of three fluvial terraces which from the oldest terrace (1st terrace) gave place for the shallow coring (Figure 4-16). The Holocene place close to the delta apex is characterized by generally horizontally bedded sandy and silty sediments being part of the topset environment of the vast delta plain.

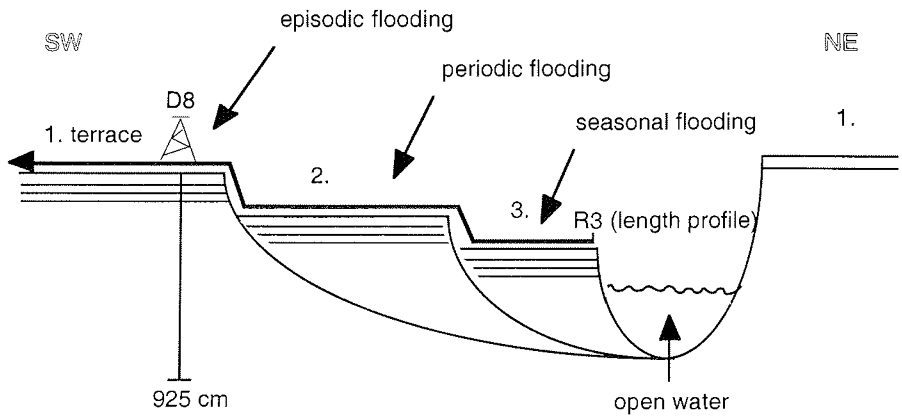


Figure 4-16: Vertical profile of Holocene sedimentary terraces near Sardakh Island including length profile of radar sounding R3.

The sediment core will be studied for the same sedimentological parameters as sediment sample sites D1, D6, and D7 including age determinations by the ^{14}C method (Figure 4-17).

Additionally, geochemical parameters for the continuous sedimentary profile are provided by measurements of TC, TOC-, N-, S-content. Permafrost properties are examined by measuring water soluble cation (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Sr^{+}, Ba^{+}, Al^{3+}, Ti^{+}, Fe^{2+}, Mn^{2+}) and anion concentrations (NO_2^-, NO_3^-, SO_4^{2-}, Cl^-, Br^-, F^-, PO_4^{3-}). In addition, pH values and electrical conductivity will be determined (see chapter 4.3.2). The work on these parameters is in progress.

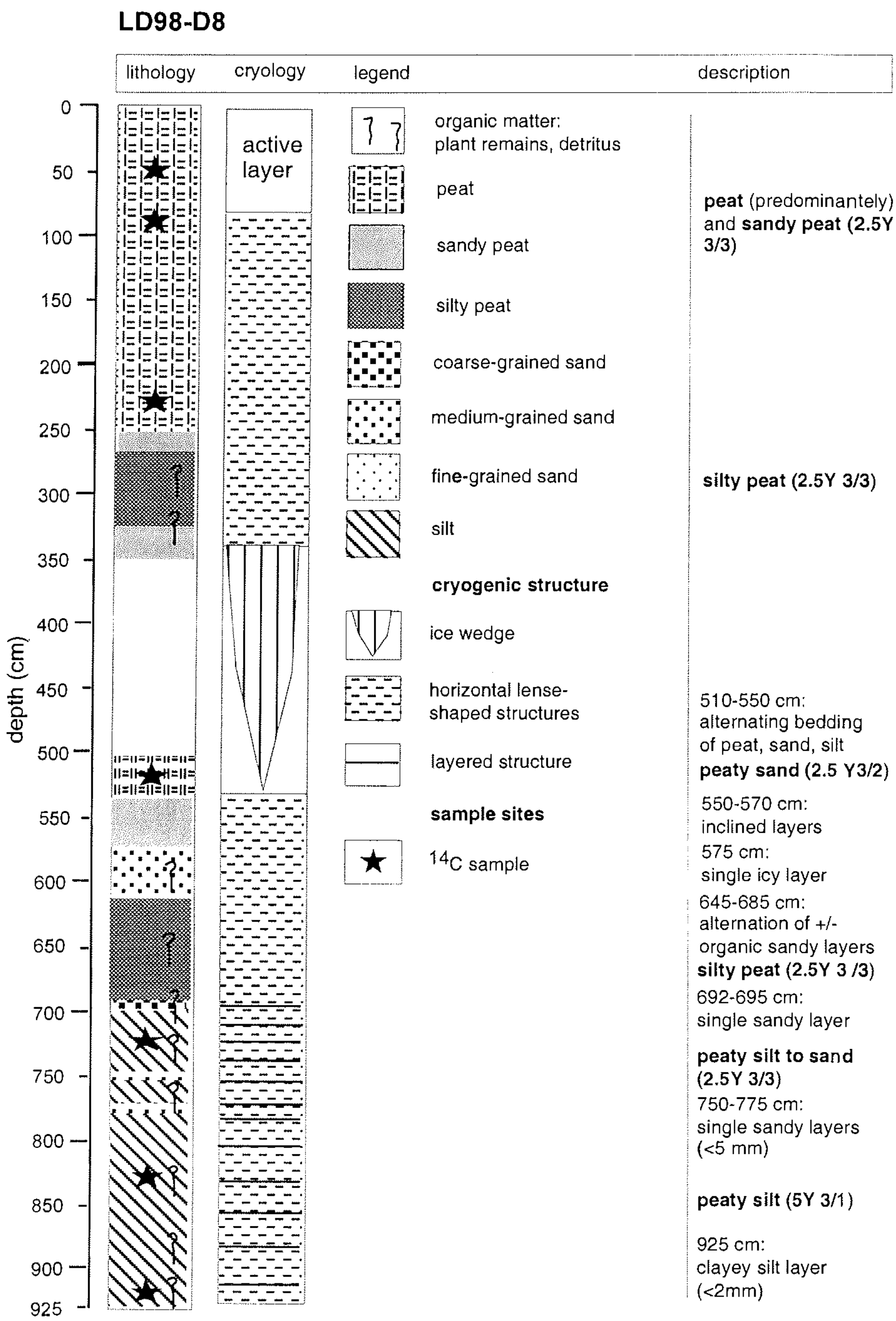


Figure 4-17: Sediment core LD98-D8 from near Sardakh Island (location N 72°33.821´, E 127°11.114´), profile of Holocene Lena sediments with cryogenic textures.

4.3.6 Field work and preliminary results at Samoylov Island

For comparison a second place for shallow coring has been chosen on Samoylov Island (Figure 4-18).

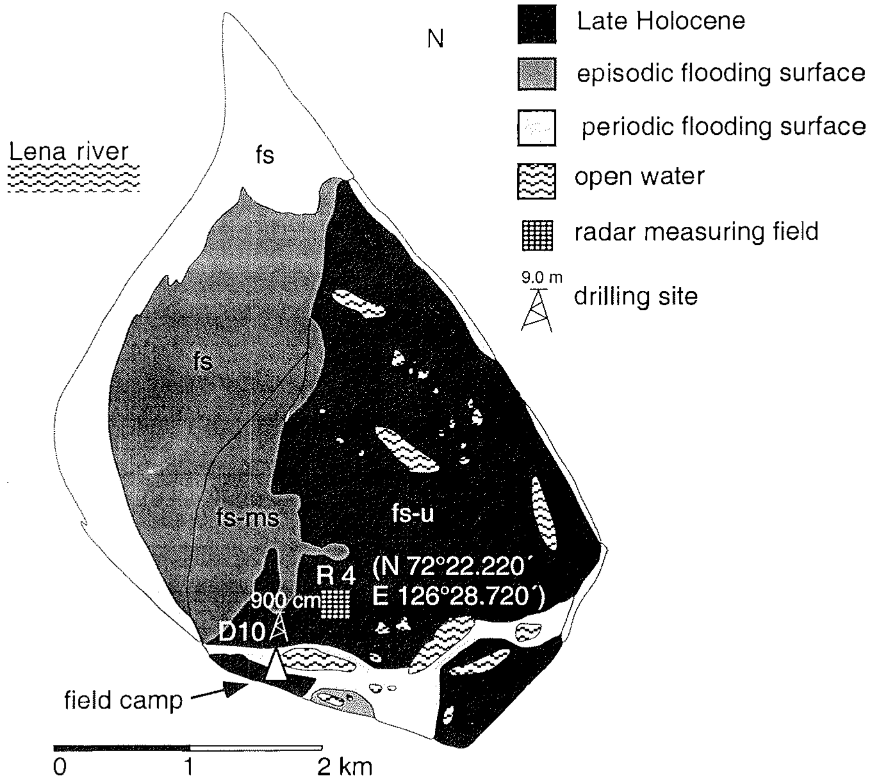


Figure 4-18: Map of Samoylov Island showing locations of radar profiling R 4 (with coordinates), sediment drilling D10 and camp site.

To reveal middle and lower Holocene top set sedimentary units the uppermost terrace was place of the drilling site. The core reached down to 900 cm (Figure 4-19). For sedimentological work on the core material see above (i.e. LD98-D08)

Drilling was accompanied by geophysical sounding measuring a field of radar profiles and velocity determinations applying the CMP method. Both sediment profiles D8 and D10 show remarkably high contents of ice up to 80 % in the peaty sections and around 60 % in the silty-sandy sections. When determining the physical and chemical characteristics of the two continuous sediment cores a special interest is given to information about sedimentation rates and the question wether they document details about Holocene aged tectonic activities of the area or water level fluctuations, respectively.

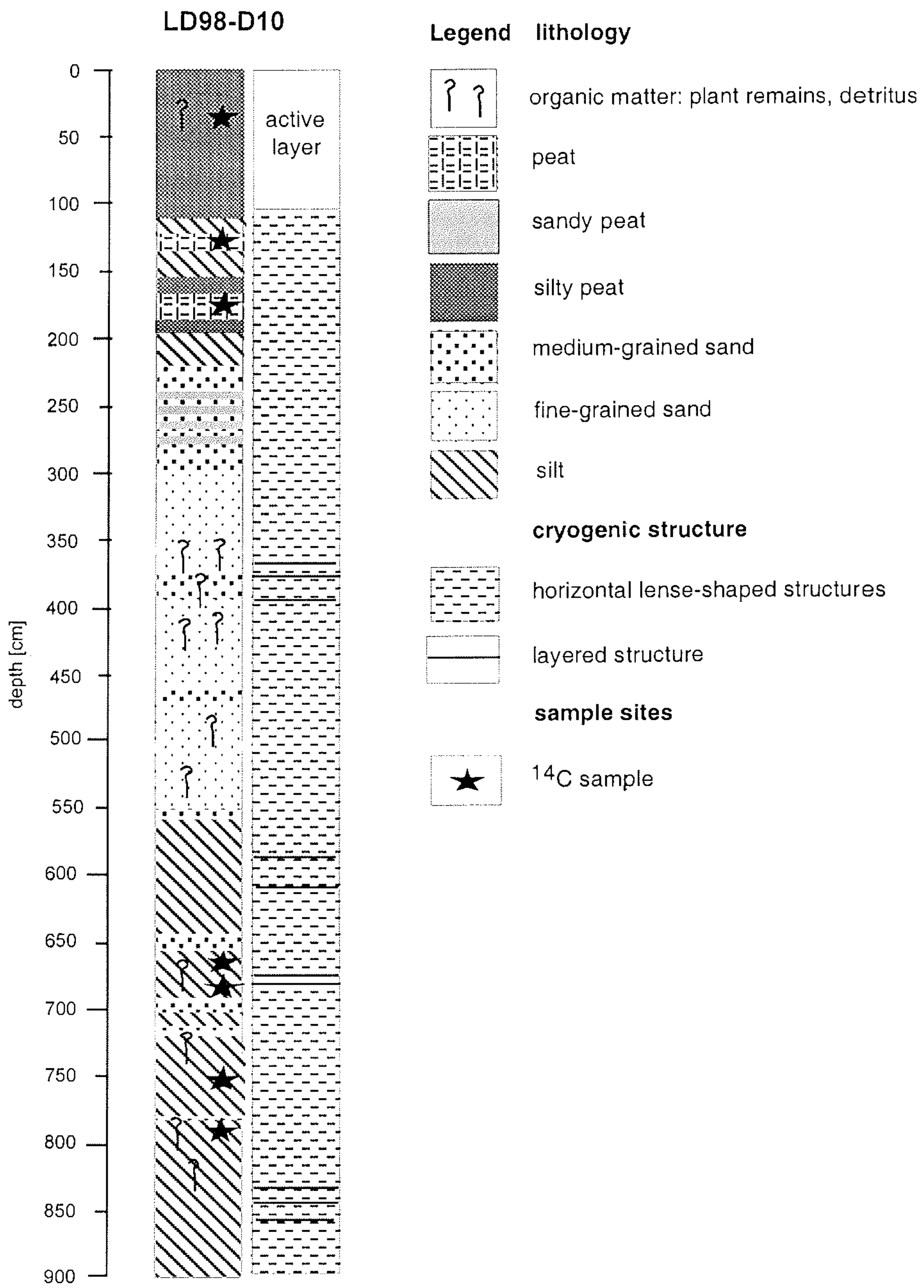


Figure 4-19: Sediment core LD98-D10 from Samoylov Island (location N 71°59.641´, E 127°05.630´), profile of Holocene Lena sediments with cryogenic textures.

4.4 Geological-Geomorphological Studies in the Northern Lena River Delta

(E. Pavlova and M. Dorozhkina)

4.4.1 Introduction

Many investigators were concerned with reconstruction of the major stages in the history of development of the Lena River delta (Gusev, 1953, 1959, and 1960; Alekseyev, 1961; Strelkov, 1965; Korzhuyev and Fedorova, 1970; Galabala, 1970 and 1987; Korotayev, 1984; Grigoryev, 1988 and 1993). In spite of sufficient knowledge, the problem of paleoclimatic conditions of the environmental development of the Lena Delta in the Pleistocene and Holocene is still unsolved. The arguments in respect of the paleogeographical conditions within the Lena Delta in the Pleistocene and Holocene primarily indicate that the convincing actual material allowing unambiguous solution of this problem is still unavailable.

Reliable reconstruction of paleoclimatic conditions of the environmental development can be made if based on a comprehensive detailed study of the most representative sections of quaternary deposits and bottom lake sediments. Such study includes spore-pollen and diatom analyses, analysis of plant remains, granulometric and other types of analysis with a compulsory determination of the absolute age of the deposits.

Currently, there is a considerable number of separate radiocarbon datings of the ice complex sections and deposits comprising the terrace levels of different heights (Korotayev, 1984; Galabala, 1987; Kunitsky, 1989; Grigoryev, 1988 and 1993). However, there are no dated spore-pollen and diatom diagrams for the Lena Delta region. The available spore-pollen diagrams without datings were made in the 1960s (Alekseyev, 1961; Giterman, 1963). They are single and by detailing, do not correspond to the current palinology level. As shown by the results of the international CAPE (Circum Arctic Paleoenvironments) Project, the Lena River delta is one of the regions of the Russian Arctic, which is completely non-covered with actual data for paleogeographic reconstruction (CAPE, 1997).

Our research mainly aims at reconstructing the paleogeographical conditions of the environmental development of the Lena River delta in the Pleistocene and Holocene to obtain quantitative paleoclimatic characteristics of mean annual temperature, the warmest and the coldest month temperature and a mean annual sum of atmospheric precipitation for millenium time slices.

The goal of the 1998 field studies was to collect the necessary full-scale data for characterizing the current state and for paleogeographic reconstructions of the environmental development of the northern Lena River delta. The major objectives of the field studies were:

- to identify and to trace the main delta terrace levels;

- to investigate the shore outcrops of channels and lakes with detailed sampling;
- to investigate the lake bottom sediments with detailed sampling;
- to set up the pollen trap stations for determining the character of pollen transfer in the delta;
- to sample lake bottom sediments for determining the content and vertical distribution of Pu-239, 240.

4.4.2 Methods

1. Identification and tracing of the main terrace levels was carried out using geological-geomorphological observations en-route along the channels and over the adjoining territory.

2. Study of the shore outcrops of channels and lakes in the Lena Delta included a detailed description and sampling for spore-pollen and diatom analyses, analysis of plant remains and radiocarbon dating. Sampling was continuous at 5 cm spacing taking into account the lithological boundaries.

3. Bottom sampling of the Lena Delta lakes was performed using a ground corer 1.5 m long designed in GOIN in the deepest lake zones. Sampling of sediment cores for paleogeographical studies (for the spore-pollen and diatom analyses and dating) was continuous at 2 cm spacing taking into account the lithological boundaries. Samples for determining the content and vertical distribution of Pu-239, 240 in bottom sediments were collected from the upper 10 cm sediment at 1 cm spacing.

4. For determining the character of pollen transfer, the pollen trap stations were set up in the Lena River delta. Deployment of pollen trap stations was performed in accordance with the requirements of the European Pollen Monitoring Program (Hicks et al., 1996).

4.4.3 Study region

The field studies were carried out in the northern Lena River delta in the segment "Yugus-Jie – Jeppiries-Tyubelege-Malaya Tumatskaya Channel – Sagastyr Island" (110 km long) (Figure 4-20). The reconnaissance observations were made along the route "Sagastyr Island – Bolshaya Tumatskaya Channel – Samoylov Island (with a length of 135 km). The study region is located in the northwestern sector of the Lena Delta where sand relics of the second late Pleistocene-early Holocene terraces with the absolute heights up to 25 m are widespread along with modern alluvial features (Grigoryev, 1993).

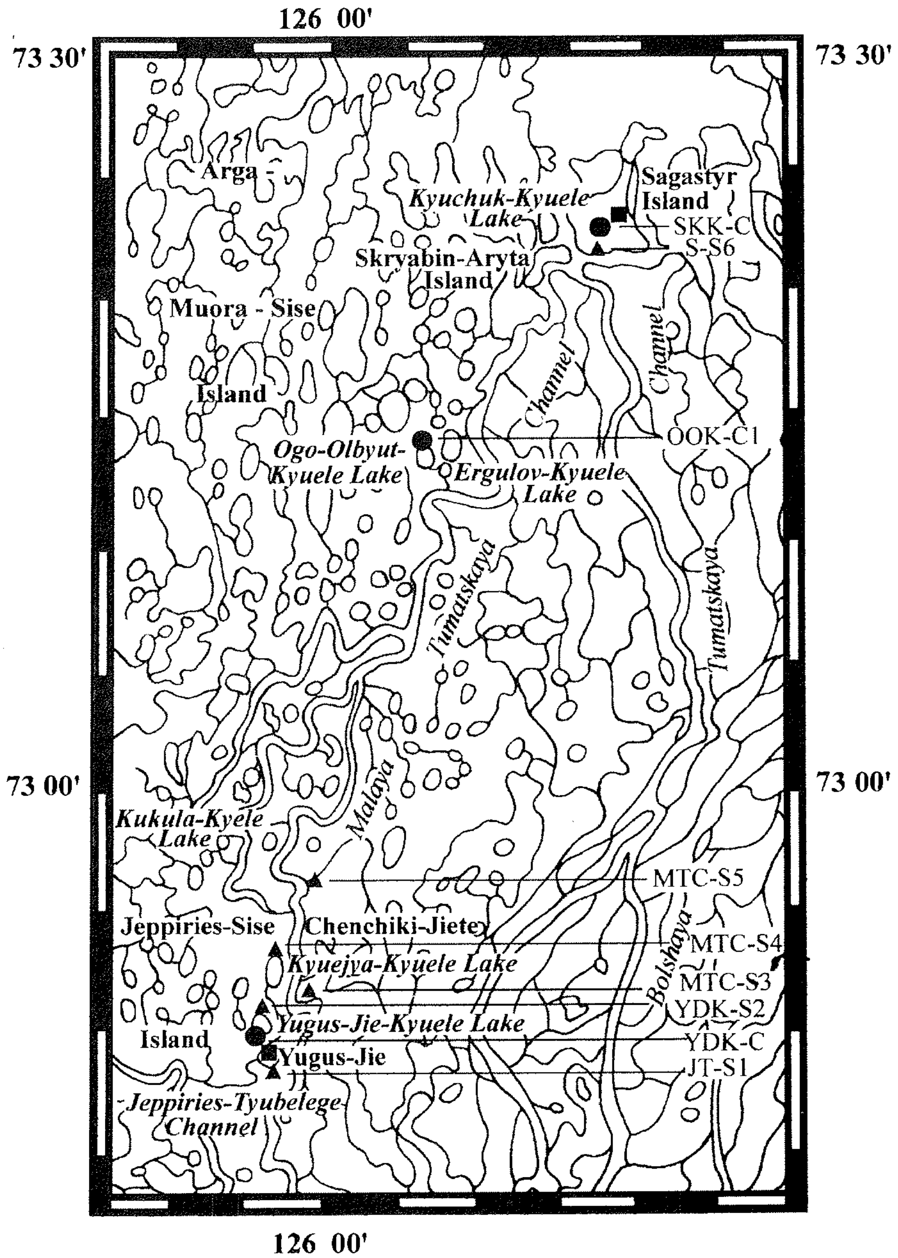


Fig 1. Data distribution map of the northern part of Lena-delta area.

▲ -section sampling

● -lake sediment sampling

■ - pollen trap station

Figure 4-20: Location map of the northern part of the Lena Delta.

The Malaya Tumatskaya Channel is one of the largest channels of the Lena Delta. The branch is oriented in the northern direction. Its length is 127 km with the channel width between 0.1 to 1.8 km. The depth of the branch is between 1 m to 23 m (in the region of its merging with the Bolshaya Tumatskaya Channel). The current speed is 0.1-0.5 m/s. With the advance to the north, the current speed decreases. Within the study region, there is a developed polygonal-bar complex of tundra bog lowland and tundra peat and peat-gley soils belonging to the permafrost tundra-Arctic type (Atlas of the Arctic, 1985).

The plant communities of the study region are represented by dwarf-shrubs and herb-dwarf shrubs (Dryas octopetata, Cassiope tetragona, Salix nummularia, Salix reptans, Luzula confusa, Poa arctica, Papaver pulvinatum, Saxifraga hirculus, Valeriana capitata), moss (Tomenthyphnum nitens) and lichen (northern and Arctic East Siberian lichen in combination with hypno-herbaceous and polygonal bogs).

4.4.4 Field work results

The following geomorphological levels were defined in the study region:

- low flood plain and a complex of modern channel forms (with 1-3 m absolute height) of recent age;
- high flood plain (with 4-7 m absolute height) of late Holocene age;
- first above the flood plain terrace (with 8-10 m absolute height) of Middle Holocene age;
- second above the flood plain terrace (with 11-18 m absolute height) of late Pleistocene-early Holocene age.

The obtained data are in agreement with a complex of earlier identified height levels (Korotayev, 1984; Grigoryev, 1993).

The low flood plain is traced by the zones of different width from first meters to 2-2.5 km along the branches (Figure 4-21). The surface of the low flood plain is sparsely covered with vegetation. The low flood plain is annually flooded by water during the flood and frequent wind-induced surges. The low flood plain deposits are represented by alluvial fine- and medium-grained sands with individual extremely rare pebble and sand-silt-clayey alternating strata with plant remains.

Active accumulation processes forming the alternating strata of sands and silt-clayey deposits with plant remains take place during wind surges at periodic flooding of the low flood plain zones covered with vegetation (Carex aquatilis, Eriophorum polystachion, E. vaginatum). Active accumulation of sand material with formation of wide sand shoals (sands of Chopporoy-Kumaga, Khoigullakh-Kumaga, Chutkuo-Kumaga, etc.), inshore shoals and spits occurs in the zones of large winding bends near the convex shores of the branches. The surface of sand shoals is flat and devoid of vegetation. Sands are wavy laminated.

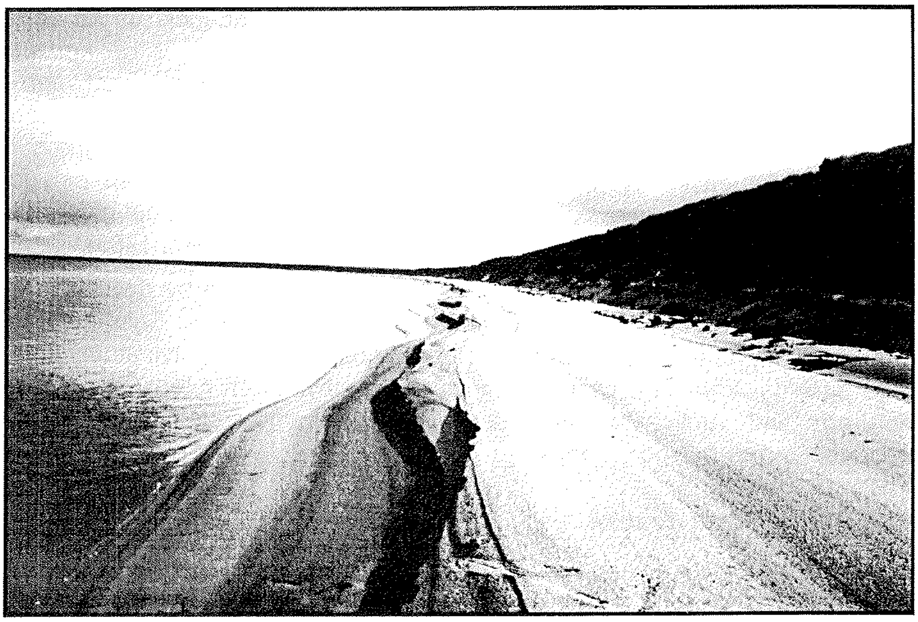


Figure 4-21: The low floodplain, left bank of the Malaya Tumatskaya Channel.

Within the northern part of Sagastyr Island at the boundary of the seaboard with the sub-aerial delta, the coastal-delta and coastal-sea deposits are actively formed. They have a considerable thickness and are widespread in area. The deposits are mainly represented by fine-grained strongly silted sands. The surface corresponding to the height level of the low flood plain within the northern Sagastyr Island is up to 1-1.5 m high extending in a band up to 1.5-3 km wide. In the southeastern part of the island, the low flood plain composed of fine-grained sands is up to 0.7 km wide. Mortlakes that are characterized by an elongated shape with a meandering coastline are widespread within the low flood plain.

As a result of the channel flow influence in some locations near the rear seam of the low flood plain a thermoerosion recess is formed up to 1.5-3 m high and up to 3-10 m deep. Ice often accumulates in such recesses that remind peculiar layers presenting ephemeral features as they are destroyed with a retrogressive motion of the thermoerosion recess (Grigoryev, 1993). This feature was observed near the rear seam of the low flood plain at a height of 2.5 m and in 600 m from the waterline of the Malaya Tumatskaya Channel on its left bank in the region of Lake Kyudzha-Kyuele.

A complex of modern channel features includes the channel bars and islands composed of alluvial sands. Their height is not more than 1 m. The surface is devoid of vegetation. The cryogenic processes within the low flood plain are manifested by the presence of separate frost clefts without a pronounced polygonal character.

A high flood plain (4-7 m) is developed everywhere over the entire length of the branches presenting the water-flooded surface during the flood only in rare individual years. Along the Malaya Tumatskaya Channel the high flood plain is represented by the zones of different width (2.5 km) attached to the relics of the first above the flood plain terrace. Along the Bolshaya Tumatskaya Channel the high flood plain is represented by a complex of large delta islands. Within Sagastyr Island, a high flood plain with a height of 2 m occupies its central and eastern regions.

In total the high flood plain sediments are represented by layered silty-sand-peat deposits. The high flood plain deposits are characterized in the MTS-S5 section (72° 57' 09" N, 125° 55' 06" E) on the right bank of the Malaya Tumatskaya Channel in 150 km upstream from the mouth of the Khalchagar-Tebyulege Channel (Figures 4-20 and 4-22). The height of the high flood plain is 5.5 m. The deposits of the MTS-S5 section from top to bottom are represented by:

- 0.00 – 0.20 m – sandy loam of brown color with plant remains;
- 0.20 - 0.80 m - layered predominantly peat stratum of reddish color with interlayers of 0.2-2 cm thick, fine- and medium-grained sand of polymict pale-yellow composition;
- 0.80 - 1.40 m - brown-colored loose peat;
- 1.40 - 1.65 m - sandy-peat alternating strata of pale yellow-brown color. Average thickness of medium-, and coarse-grained sand and peat interlayers is 1.5-2 cm. The maximum peat interlayer is 5 cm thick.
- 1.65 - 2.10 m - brown-colored layered peat with separate rare interlayers of fine-grained sand up to 1 mm thick;
- 2.10 - 2.20 m - brown-colored peat with frequent interlayers of fine-grained pale-yellow sand;
- 2.20 - 2.50 m - fine- and close-grained humic, layered sand of dark pale-yellow color. Lamination is governed by thin dark interlayers of well-decomposed organic matter;
- 2.50 - 2.93 m - dark-brown slightly decayed peat. In the 2.65 to 2.78 m interval there is an ice interlayer ;
- 2.93 - 3.18 m - sand-peat alternating strata of pale-yellow color. The thickness of peat interlayers is up to 5 cm with the thickness of interlayers of fine- and medium-grained sand up to 3 cm;
- 3.18 - 3.30 m - ice interlayer;
- 3.30 - 3.40 m - yellow-colored, fine- and close-grained wavy laminated sand with silt interlayers of grey color 0.1-0.4 cm thick;
- 3.40 - 3.55 m - silty-sandy peat alternating strata of brownish-grey color;
- 3.55 - 4.70 m - pale-yellow-colored fine-grained sands with ferrugination lenses of elongated ellipse-like shape. The location of lenses creates an effect of oblique lamination.

The high flood plain deposits have a large ice content and a developed lens-shaped, layered and reticulate structure (Figure 4-22). Everywhere in coastal outcrops of the high flood plain, there are exposures of recurrent ice veins. The width of the ice veins reaches 2.5-3 m and their visible vertical thickness is up to 2.5 m. The distance between the veins is 5-8 m.

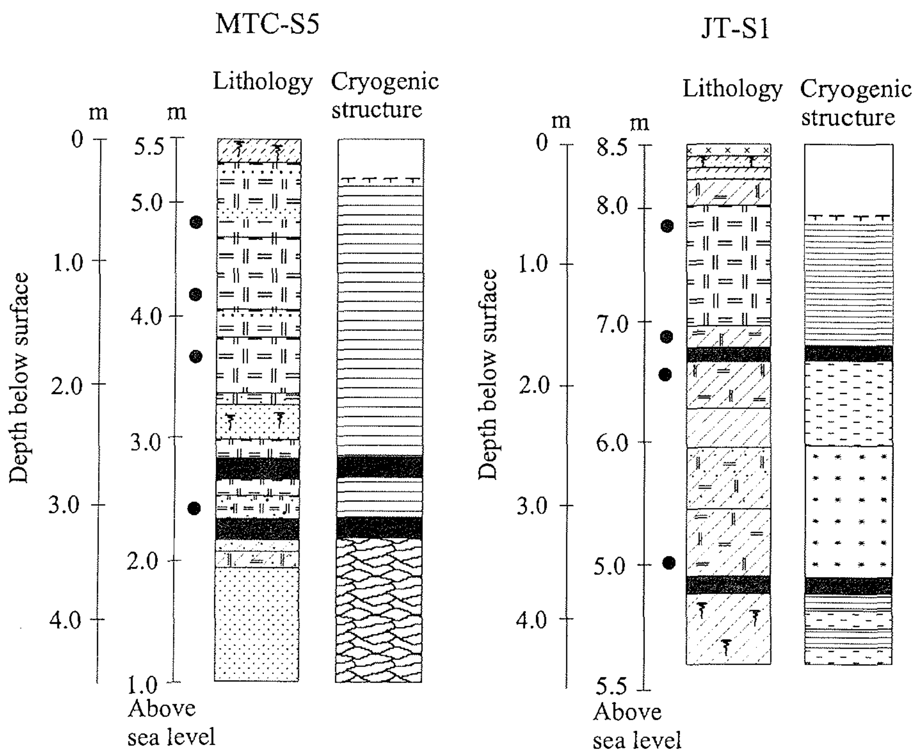


Figure 4-22: Typical cryolithological section of the northern part of the Lena Delta.

The high flood plain surface has a widely developed polygonal and polygonal-bar microrelief. The polygons are characterized by a quadrangular shape and reach up to 10-11 m in the cross-section. The central depressed polygon zones are swamped. The seasonal melting depth within the high flood plain was 25-30 cm during the observation period July 19 to August 17.

The thermoerosion processes cause intense destruction of the high flood plain. The shore destruction results from caving of large (3-8 m) soil blocks that are separated along the cracks and thermoerosion grooves located along the ice veins. The formation of the thermoerosion recess (see above) up to 3 m height above the waterline contributes to acceleration of the block caving (Figure 4-23).

Widespread mortlakes and thermokarst lakes characterize the high flood plain. The mortlakes have an elongated shape with a meandering coastline reaching 1 km in length. The thermokarst lakes resulting from melting of ice saturated deposits and recurrent ice veins are characterized by the round contours in the plan.

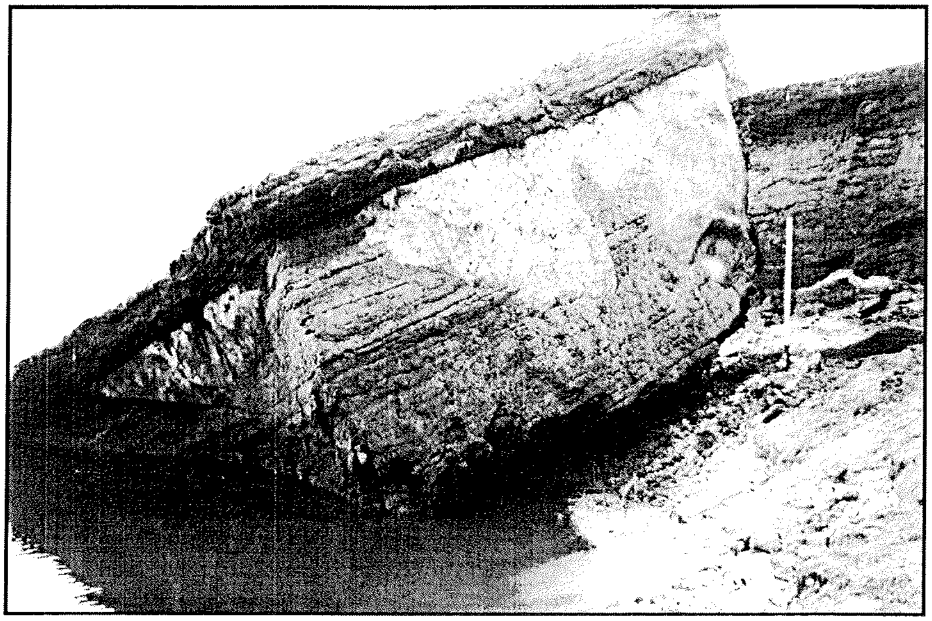


Figure 4-23: The character of shore destruction of the high flood plain. Right bank of the Malaya Tumatskaya Channel.

Lake Ogo-Olbyut-Kyuele situated in the easternmost part of Island Arga-Muora-Sise is confined to the height level of the high flood plain. The lake area is 1 km^2, the coastline length is 3.6 km and the depth is 5.5 m. The lake shores are low and swamped. The lake basin is surrounded with sand relics of the second above the flood plain terrace. At present, the lake is practically drainless. In normal years the watershed between Lakes Ogo-Olbyut-Kyuele and Ergulov-Kyuele prevents water drainage from Lake Ogo-Olbyut-Kyuele to the Malaya Tumatskaya Channel. In some years with a high flood level, water mass penetration from the Malaya Tumatskaya Channel to Lake Ogo-Olbyut-Kyuele is possible through the Ergulov Kyuele along the shallow branch.

In the deepest central part of the lake a 0.82 m long bottom sediment core OOK-C1 was retrieved (73° 14' 30" N, 126° 11' 00" E) (see Figure 4-20). The lake sediments from top to bottom are represented:

- 0.00 - 0.24 m - sandy greenish-grey-colored silt with intermittent interlayers of black organic matter;
- 0.24 - 0.26 m - black-colored silt with plant remains in the form of fibers;
- 0.26 - 0.82 m - sandy greenish-black colored silt with individual fibers of plant remains.

The first above the flood-plain terrace (with 8-10 m absolute marks) is spread along the branches presenting either local island segments of different width or flat surfaces leaning against the relics of the second flood plain. Downstream, the height level of the first above the flood plain decreases reaching 4 m absolute height in the eastern part of Skryabin-Aryta Island and the 3.5 m absolute height in the southern part of Sagastyr Island.

The composition of the deposits of the first above the flood plain terrace is similar to that of the high flood plain sediments being represented by silt-sand-peat deposits. One of the typical sediment sections of the first above the flood plain terrace is section JT-S1 (72° 49' 45" N, 125° 49' 40" E) situated on the right bank of the Jeppiries-Tyubelege Channel (see Figure 4-20 and 4-22). The absolute shore height is 8.5 m. The deposits of section JT-S1 from top to bottom are represented by:

- 0.00 - 0.10 m - soil;
- 0.10 - 0.20 m - sandy loam of grey color with plant remains;
- 0.20 - 0.30 m- heavy sandy loam of dark-grey color with ferrugination red-colored spots with plant remains;
- 0.30 - 0.50 m - peaty silt alternating strata. The peat interlayers are of red-brown color with 1-1.5 m thickness, which decreases upward the section. The silt interlayers are of dark-grey color with 1.5-2 cm thickness, which increases upward the section;
- 0.50 - 1.50 m - brown to black fibrous, non-layered peat;
- 1.50 - 1.70 m - red-colored, fibrous, loose peat with thin interlayers of grey-colored silt;
- 1.70 - 1.86 m - ice;
- 1.86 -2.26 m - peat-silt alternating strata of dark-grey color. The thickness of peat interlayers is up to 1 cm. The thickness of silt interlayers is up to 5-7 cm. Within the 1.90 to 2.26 m interval, two tree trunks were observed with oblique bedding (with 10° sloping angle to the horizontal surface and located at 100° angle to the outcrop wall);
- 2.26 - 2.56 m - dark-grey colored, micaseous, non-layered silt with rare single plant fibers;
- 2.56 - 2.99 m - silt-sand-peat alternating strata. Dark-grey micaseous silt interlayers with the up to 0.1 - 0.5 cm thickness. Fine-, close-grained micaseous sand interlayers of dark-grey color up to 5 cm thick. Brown, compact, cardboard-like peat interlayers up to 10 cm thick;
- 2.99- 3.24 m- silt-peat alternating strata;
- 3.24 - 3.54 m - red-colored fibrous peat with silt interlayers up to 0.3 cm.
- 3.54 - 3.69 m - ice;
- 3.69 - 4.29 m - silt of dark-grey color with plant remains in the form of fibers.

Along the Malaya Tumatskaya Channel the deposits of the first above the flood plain terrace are characterized in the MTS-S3 section (72° 51' 58" N, 125° 55' 08" E) on the right bank of the branch (see Figure 4-20 and 4-24). The absolute shore height is 9.0 m. The description is from top to bottom:

- 0.00 - 0.75 m - silt-peat-sand alternating strata. The thickness of interlayers of pale-yellow inequigranular sands of polymict composition is up to 6 cm, grey silts are 1-2 cm and peat layers up to 1 cm thick. Lamination is horizontal;
- 0.75 - 1.05 m - peat-sand alternating strata. Brown-colored, loose and fibrous peat with 1.5-6 cm thickness of interlayers. Pale-yellow medium- and coarse-grained polymict sands with 2-6 cm thickness of interlayers. Lamination is horizontal;
- 1.05 -1.85 m -silt-sand-peat alternating strata. Dark-grey-colored silt with the thickness of interlayers up to 1 cm. Pale-yellow fine-grained polymict sand with the thickness of interlayers up to 1 cm. Peat is brown-colored and loose, the plant remains are slightly decayed and the thickness of interlayers is 1.5-6 cm. Lamination is wavy. In the 1.65 to 1.73 m interval there is a tree trunk;

- 1.85 -3.95 m - silt-peat alternating strata. The thickness of grey silt and brown peat interlayers is up to 1 cm. Lamination is plicational.

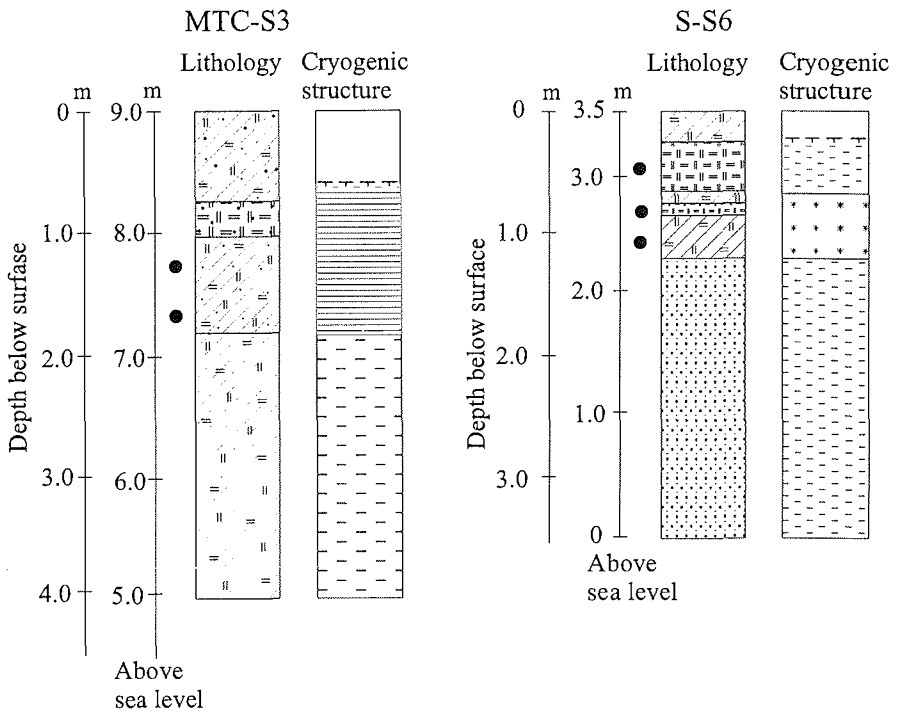


Figure 4-24: Cryolithological section of the first above the flood plain terrace.

In the northern Lena River delta, the deposits of the first above the flood plain terrace were outstripped in S-S6 section (73°22' 17" N, 126° 33' 50" E) on the southern shore of Sagastyr Island (see Figures 4-20 and 4-24). The absolute shore height is 3.5 m. The section is described from top to bottom:

- 0.00 - 0.02 m - soil-vegetation layer;
- 0.02 - 0.25 m - silt-peat alternating strata. Grey-colored micaseous silt with up to 3 cm thickness of interlayers. Brown-colored, cardboard-like peat, the organic remains are slightly decayed, the thickness of interlayers is up to 3 cm;
- 0.25 - 0.65 m - yellow-red-colored, loose peat with well-decomposed organic matter;
- 0.65 - 0.75 m - silt-peat alternating strata. Micaseous, grey-colored silt; red-colored loose fibrous peat. The thickness of interlayers is 0.5 to 1 cm.
- 0.75 - 0.85 m - yellow-red-colored, loose peat with well-decomposed organic matter;
- 0.85 - 1.20 m - silt-peat alternating strata. Grey-colored micaseous silt, the thickness of interlayers varies between 1 mm and 3 cm. Yellow-red to brown-colored peat of different density (loose to very compact) with different decomposition degree of organic matter. The thickness of peat interlayers is 1-5 cm.
- 1.20 - 3.50 m - pale-yellow colored, fine- and medium-grained quartz sands, horizontally layered.

The very icy deposits of the first above the flood plain terrace are characterized by the development of massive, lens-shaped cryogenic structures. The recurrent ice veins are widespread in the deposits (see Figure 4-24). In shore exposures of the first above the flood plain terrace, the outcrops of ice veins can be observed. The vein width in the upper portion is 0.9-1.6 m, the visible vertical thickness is up to 2.5 m and the distance between the individual veins is 11-13 m. The ice veins are often overlapped by layered peat-silt deposits 0.6-0.8 m thick.

The flat hillocky surface of the first above the flood plain terrace is characterized by the development of the polygonal and polygonal-bar microrelief. In the far north part of study region (for example, Sagastyr Island) widespread polygonal-bar microrelief characterizes first above the flood plain terrace. In total the first above the flood plain surface has a widely developed plane polygonal microrelief. The polygons are often of a regular rectangular shape with dimensions up to 12-15 m in the cross-section. The depth of the cracks separating the polygons reaches 1.5-1.8 m. The central zones of polygons are swamped and often occupied by small lakes.

The seasonal melting depth at the time of observation was 0.6 m (July 21) for the Jeppiries-Tyubelege Channel, 0.6 m (July 26) for the Malaya Tumatskaya Channel and 0.25 m (August 15) for Sagastyr Island.

Along the shores of the branches in recurrent ice veins, bedding of thermoerosion grooves occurs. The process of shore destruction of the first above the flood plain terrace is similar to the character of shore destruction of the high flood plain.

At the surface of the first above the flood plain terrace, round-shaped lakes are developed with smooth coastline contours. One of such lakes is Lake Yugus-Jie-Kyuele situated in the southeastern part of Jeppiries Island. The lake is located at the surface of the first above the flood plain terrace (8-9 m), leaning against the second above the flood plain terrace relic with a maximum elevation of 13.4 m. The waterline has an absolute height of 6.4 m. The lake area is 1.6 km^2, the coastline length is 4.3 km and the lake depth is 6.3 m. Along the southern and southwestern gently sloping lake shore, a lake terrace 1.5-2 m above the waterline with a width of 150-220 m is observed. The terrace is composed of fine- and medium-grained sands with silt. The terrace surface is swamped. A similar lake terrace is observed on the northeastern lake shore. The northwestern and eastern lake shores are steep and precipitous with 5-6 m height and are formed from sand deposits of the second above the flood plain terrace relics.

In the deepest central part of the lake a 0.37 m long bottom sediment core YDK-C2 was retrieved (72° 51' 04" N, 125° 49' 07"E) (see Figure 4-20). The lake deposits from top to bottom are represented by:

- 0.00 - 0.14 m - clayey silt of grey color with plant remains in the form of fibers;
- 0.14 - 0.21 m - alternating thin interlayers of clayey silt and fine-grained quartz sand;
- 0.21 - 0.37 m - clayey silt of greenish-grey color with plant remains.

As compared with the high flood plain, the mortlakes within the first above the flood plain terrace are developed to a lesser extent, being characterized by significant reworking and smaller coastline meandering.

A significant number of mortlakes are observed in the southwestern part of Sagastyr Island. The lakes are narrow and have a typical linear-elongated shape. Their depths vary from 1 to 1.2 m. One of such lakes is Lake Kyuchuk-Kyuele. The lake is extended in the submeridional direction, its area is 0.3 km^2, the coastline length is 2.4 km and the depth is 1.2 m.

In the central part of the lake a 0.33 m long bottom sediment core SKK-C2 was retrieved (73° 23' 05" N, 126° 35' 20" E) (see Figure 4-20). The lake deposits from top to bottom are represented by:

- 0.00 - 0.33 m - grey-colored silt with non-decomposed plant detritus of greenish-brown color without the indications of lamination. The lower 4 cm are in the frozen state (ice).

The second above the flood plain terrace has a fragmentary development in the form of relics with the absolute top marks of 11-18 m. The relics of the second above the flood plain terrace sharply differ from the other terrace levels by lithology of deposits, geomophological habit and the character of the vegetation cover.

The relic deposits differ by a uniform composition and structure. They are predominantly represented by fine- and medium-grained quartz sands, which are sub-horizontal and obliquely layered.

The deposits of the second above the flood plain terrace are characterized in the YDK-S2 section (72° 51' 14" N, 125° 50' 22" E) on the northeastern shore of Lake Yugus-Jie-Kyuele (see Figures 4-20 and 4-25). The absolute shore height is 11 m. The description is from top to bottom:

- 0.00 - 0.72 m - fine- and medium-grained pale-yellow, polymict sub-horizontally layered sands with ferrugination spots and leaks of ocherous color;
- 0.72 - 0.74 m - alternating thin lamina of well-decomposed organic matter and fine- and medium-grained sands of pale-yellow color;
- 0.74 - 2.00 m - fine- and medium-grained pale-yellow, polymict sub-horizontally layered sands with ferrugination spots;
- 2.00 - 2.45 m - alternating strata of brown-colored peat with fine- and medium-grained pale-yellow sand. The thickness of peat interlayers increases from top down the section ranging from 0.5 to 4 cm. The thickness of sand interlayers decreases from top down ranging from 4 to 0.3 cm. The character of lamination is wavy;
- 2.45 - 2.65 m - peat. Within the 2.45 to 2.50 m interval, there is brown-colored cardboard-like peat with fine-grained sand interlayers 1-1.5 mm thick. Within the 2.50 to 2.56 m interval, there is black-colored, very compact and fatty cardboard-like peat with an insignificant content of silt particles;
- 2.65 - 2.96 m - fine- and medium-grained pale-yellow, polymict non-layered sands with separate plant remains. Ferrugination spots and leaks of ocherous color are noted;
- 2.96 - 4.50 m - fine- and medium-grained pale-yellow, polymict sands with ferrugination spots.

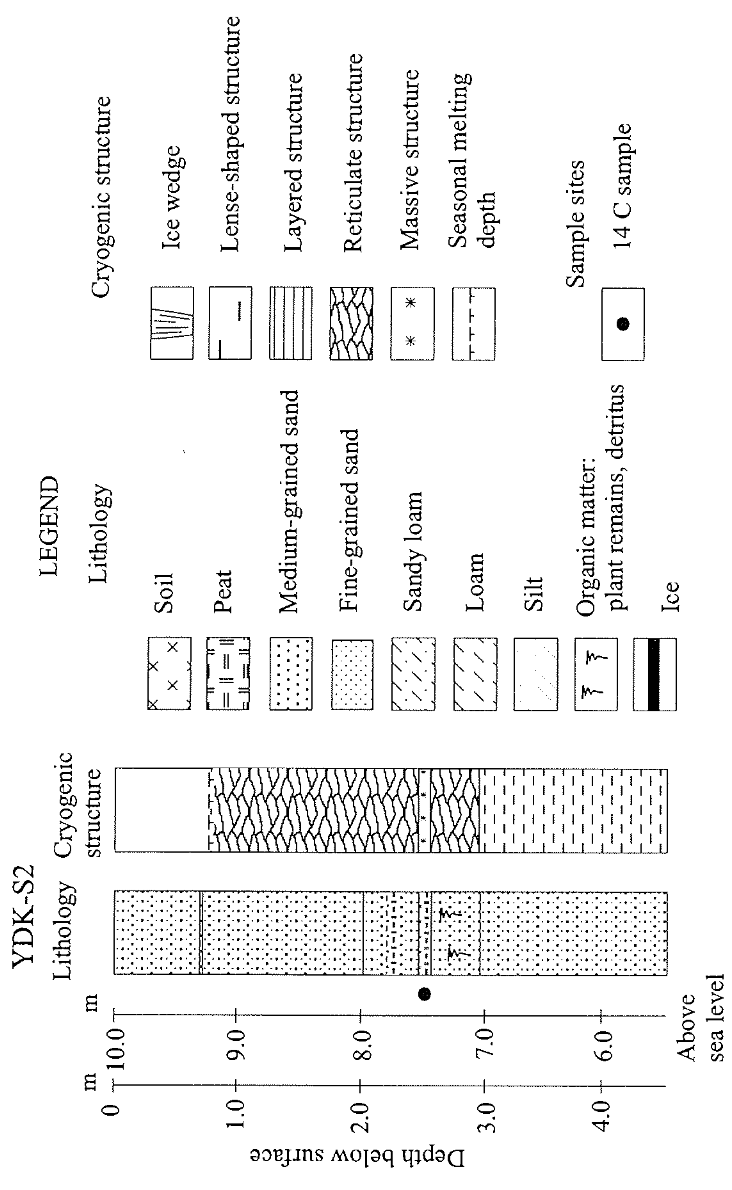


Figure 4-25: Cryolithological section of the second above the flood plain terrace.

Permafrost deposits of the second above the flood plain terrace are characterized by the development of reticulate, lens-shaped and massive cryogenic structures (see Figure 4-25). Sand deposits are characterized by widespread ice layers (Grigoryev, 1993).

The polygonal microrelief character at the surface of relics is less expressed than at lower terrace levels. Frost clefts are developed at the surface forming polygons up to 10-13 m in the cross-section.

The seasonal melting depth was 0.7 m (July 23) in the region of Lake Yugus-Jie-Kyuele and 1.2 m (July 27) in the region of Lake Kyuejya-Kyuele.

At the slopes of relics of the second above the flood plain terrace, thermoerosion ravines bedding along the recurrent ice veins are developed. In the longitudinal profile, the ravines are V-shaped. The depth of the ravines reaches 7-9 m.

As a result of melting of recurrent ice veins and erosion of sandy-icy deposits, there is intense bedding of thermoerosion grooves and ravines along the shores of the branches with the formation of the erosion crest relief.

At the surface of the second above the flood plain terrace relics, there are active processes of formation of micro-hillocky sands – a complex of sandy irregular-shaped micro-hillocks (Figure 4-26). The height of the hillocks is up to 0.5-0.6 m. The location is non-systematic, among the hillocks separate small deflation troughs are scattered. The hillock slopes do not display clear differentiation into lee- and windward. The hillocks are covered with sparse specific vegetation: Salix nummularia, Artemisia tilesii, A. serissima, A. borealis, Armeria maritima, Papaver pulvinatum and others (Table A4-4, appendix). Micro-hillocky sands are formed as a result of recurrent deflation of earlier fixed sands. This process is most pronounced along the shores of large lakes and along the branches.

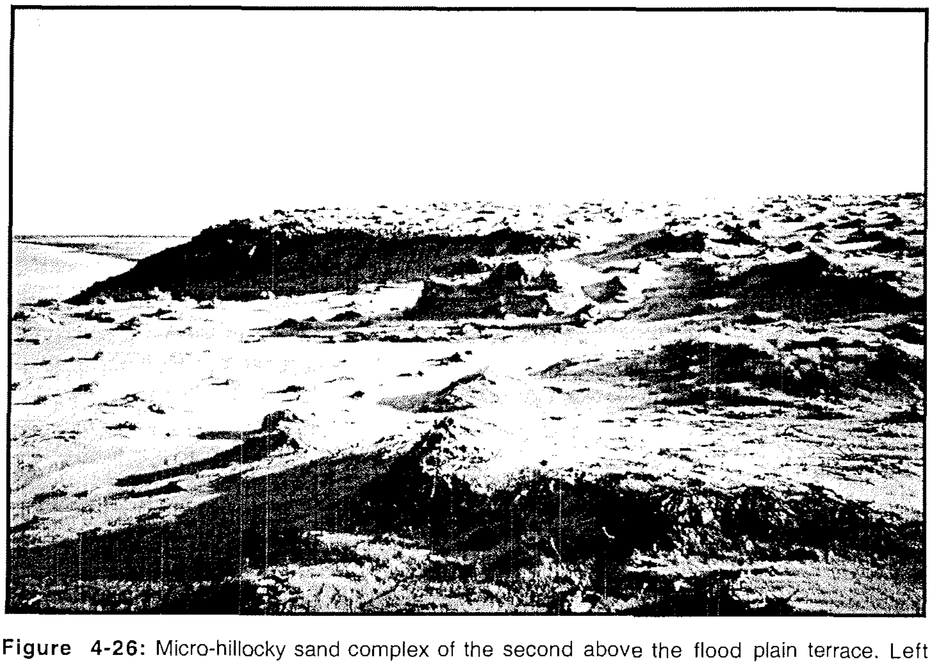


Figure 4-26: Micro-hillocky sand complex of the second above the flood plain terrace. Left bank of the Malaya Tumatskaya Channel.

In the Lena River delta, three pollen trap stations were set up:

- L-1 in Yugus-Jie with coordinates: 72° 50' 17" N, 125° 49' 15" E;
- L-2 on Sagastyr Island with coordinates: 73° 23' 14" N, 126° 36' 53" E;
- L-3 on Samoylov Island with coordinates 72° 22' 43" N, 126° 31' 08" E.

The deployment of three pollen trap stations along the meridional profile of the Lena River delta will allow us to reveal the peculiar features of redistribution of local and transit of long-distant spores and pollen within the delta. Knowledge of current spores and pollen transfer features in the delta will enable a much better quality of interpretation of the spore-pollen analysis data and paleogeographical reconstructions.

A herbarium was collected in the Lena Delta along the study route. In the region of traps, the herbarium was collected within a 100-m range from the trap. A complete list of plants is presented in the appendix (Table A4-4).

4.4.5 Conclusions

As a result of the field work the major geomorphological levels were revealed and traced, each height level was characterized by a representative section of quaternary deposits and the composition and structure of the upper strata of bottom lake sediments was determined. Samples for the spore-pollen and diatom analyses, plant remains analysis and dating were collected from the sections and lake cores of quaternary deposits. For the first time, the spore-pollen traps were set up for revealing the character of pollen transfer in the Lena Delta.

The information collected will serve as a basis for obtaining comparable data with subsequent detailed paleogeographical reconstructions of environmental development in the Lena River delta in the Pleistocene and Holocene.

4.4.6 Acknowledgments

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4.6 Appendix

Table A4-1: List of stations for hydrological, sedimentological and geophysical investigations.

Station	Date	GMT	Position		Description	Sampling
LD98-D01	08/03	2:00	73°18.98´	124°12.87´	Arga Island	Permafrost sediments
LD98-D02	08/03	2:45	73°19.58´	124°12.42´	Nikolay Lake	Lake sediments
LD98-D03	08/03	4:10	73°19.98´	124°07.95´	Nikolay Lake	Lake sediments
LD98-D04	08/03	5:50	73°20.60´	124°10.27´	Nikolay Lake	Lake sediments
LD98-D05	08/03	6:20	73°20.84´	124°11.07´	Nikolay Lake	Lake sediments
LD98-D06	08/07	0:30	72°52.81´	123°12.50´	Olenyok Ch.	Permafrost sediments
LD98-D07	08/09	2:50	72°20.71´	126°18.75´	Olenyok Ch.	Permafrost sediments
LD98-D08	08/14	0:00	72°33.82´	127°11.11´	Sardakh Ch.	Permafrost sediments
LD98-D09	08/17	6:00	72°34.90´	127°15.50´	Sardakh Ch.	Permafrost sediments
LD98-D10	08/19	0:00	72°22.19´	126°28.61´	Samoylov Island	Permafrost sediments
LD98-S01	08/01	0:00	73°19.58´	124°12.42´	Nikolay Lake	Shallow seismic profile
LD98-S02	08/01	1:00	73°19.58´	124°12.42´	Nikolay Lake	Shallow seismic profile
LD98-S03	08/01	2:00	73°19.58´	124°12.42´	Nikolay Lake	Shallow seismic profile
LD98-S04	08/01	3:00	73°19.58´	124°12.42´	Nikolay Lake	Shallow seismic profile
LD98-S05	08/01	4:00	73°19.58´	124°12.42´	Nikolay Lake	Shallow seismic profile
LD98-S06	08/02	0:00	73°19.58´	124°12.40´	Nikolay Lake	Shallow seismic profile
LD98-S07	08/02	1:00	73°19.58´	124°12.40´	Nikolay Lake	Shallow seismic profile
LD98-S08	08/02	2:00	73°19.58´	124°12.40´	Nikolay Lake	Shallow seismic profile
LD98-S09	08/02	3:00	73°19.58´	124°12.40´	Nikolay Lake	Shallow seismic profile
LD98-S10	08/02	4:00	73°19.58´	124°12.40´	Nikolay Lake	Shallow seismic profile
LD98-S11	08/02	5:00	73°19.58´	124°12.40´	Nikolay Lake	Shallow seismic profile
LD98-R01	07/31	0:00	73°18.98´	124°12.87´	Arga Island	Radar profiles
LD98-R02	08/02	10:30	73°20.31´	124°12.31´	Nikolay Lake	Radar profiles
LD98-R03	08/09	1:00	72°22.19´	126°28.72´	Samoylov Island	Radar profiles
LD98-R04	08/16	8:00	72°33.82´	127°11.11´	Sardakh Ch.	Radar profiles
LD98-W01	07/25	2:00	72°22.10´	126°47.46´	Olenyokskaya Ch.	CDT, suspended load
LD98-W02	08/07	15:30	72°52.81´	123°12.50´	Olenyokskaya Ch.	CDT, suspended load
LD98-W03	08/08	3:45	72°46.32'	124°00.11'	Olenyokskaya Ch.	CDT
LD98-W04	08/09	2:50	72°27.33´	126°21.79´	Tumatskaya Ch.	CDT, suspended load
LD98-W05	08/11	9:20	71°58.50´	130°45.75´	Laptev Sea	CDT, suspended load
LD98-W06	08/11	10:35	71°58.50´	130°32.17´	Laptev Sea	CDT
LD98-W07	08/11	11:45	71°58.50´	130°19.33´	Laptev Sea	CDT, suspended load

Table A4-1: continuation

Station	Date	GMT	Position		Description	Sampling
LD98-W08	08/11	12:35	71°58.50´	130°07.67´	Laptev Sea	CDT
LD98-W09	08/11	13:20	71°58.50´	129°55.00´	Laptev Sea	CDT, suspended load
LD98-W10	08/11	14:05	71°58.50´	129°42.30´	Laptev Sea	CDT
LD98-W11	08/11	15:10	71°58.50´	129°30.00´	Laptev Sea	CDT, suspended load
LD98-W12	08/12	3:30	71°58.88´	129°21.70´	Laptev Sea	CDT, suspended load
LD98-W13	08/12	4:30	72°00.90´	129°05.37´	Laptev Sea	CDT, suspended load
LD98-W14	08/12	5:30	72°01.53´	128°53.92´	Bykovskaya Ch.	CDT, suspended load
LD98-W15	08/12	6:10	72°02.77´	128°43.14´	Bykovskaya Ch.	CDT, suspended load
LD98-W16	08/12	10:35	72°12.02´	128°03.73´	Bykovskaya Ch.	CDT
LD98-W17	08/13	6:45	72°31.83	126°49.86´	Trofimoskaya Ch.	CDT, suspended load

Table A4-2: List of samples for sedimentological and geochemical investigations.

sediment site	substrate	depth / altitude	no. of samples	type of analyses: mineralogical: grain size	heavy minerals	SEM	geochemical: ice / water content	TC,TOC,N,S	pH, conductivity, anions, cations	geochronologcial: OSL	C14
PS=permafrost sd. LS=lake seds.											
LD98-D01 (PS)	fine-silty sand	0-355 cm (ab. Nikolay lake level)	12	x	x	x	x	x		5x	2x
LD98-D02 (LS)	fine-silty sand	0-24 cm (Nikolay lake bottom)	12	x			x	x			
LD98-D03 (LS)	fine-silty sand	0-30 cm (Nikolay lake bottom)	16	x			x	x			
LD98-D04 (LS)	fine-silty sand	0-34 cm (Nikolay lake bottom)	17	x			x	x			2x
LD98-D05 (LS)	fine-silty sand	0-12 cm (Nikolay lake bottom)	6	x			x	x			
LD98-D06 (PS)	peat, peaty sand, fine-silty sand	285-1100 cm (ab. Lena water level)	25	x	x	x		x		6x	2x
LD98-D07 (PS)	peat, peaty sand, fine-silty sand	390-1600 cm (ab. Lena water level)	18	x	x	x		x		3x	5x
LD98-D08 (PS)	peat, peaty sand, fine-silty sand	0-925 cm (below surface)	182	x			x	x	x		5x
LD98-D09 (PS)	fine-silty sand	840-900 cm (ab. Lena water level)	4	x	x	x		x			
LD98-D10 (PS)	peat, peaty sand, fine-silty sand	0-900 cm (below surface)	94	x			x	x	x		7x

Table A4-3: List of samples for Geological-Geomorphological Studies in the Northern Lena River Delta (abbreviations see end of table).

Study site JT-S1: Terrace of the Jeppiries-Tyubelege Channel (72° 49' 45" N, 125° 49' 40" E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
JT-S1 - 1	1,90-2,00	wood				x	
JT-S1 - 2	0,57-0,63	peat	x	x	x	x	
JT-S1 - 3	4,24-4,29	silt with organic matter	x				
JT-S1 - 4	4,19-4,24			x	x		
JT-S1 - 5	4,14-4,19		x				
JT-S1 - 6	4,09-4,14	silt		x			
JT-S1 - 7	4,04-4,09	silt with organic matter	x				
JT-S1 - 8	3,99-4,04			x	x		
JT-S1 - 9	3,94-3,99	silt	x				
JT-S1 - 10	3,89-3,94			x			
JT-S1 -11	3,84-3,89	silt with organic matter	x				
JT-S1 - 12	3,79-3,84			x	x		
JT-S1 - 13	3,74-3,79		x				
JT-S1 - 14	3,69-3,74			x	x		
JT-S1 - 15	3,64-3,69	silt	x				
JT-S1 - 17	3,49-3,54	peat with silty interbeds		x	x		
JT-S1 - 18	3,44-3,49		x				
JT-S1 - 19	3,39-3,44			x	x		
JT-S1 - 20	3,34-3,39		x				
JT-S1 - 21	3,29-3,34			x	x		
JT-S1 - 22	3,24-3,29		x				
JT-S1 - 23	3,19-3,24	alternating bedding of peat, silt		x			
JT-S1 -23a	3,14-3,19		x				
JT-S1 - 24	3,09-3,14			x	x		
JT-S1 - 25	3,04-3,09		x				
JT-S1 - 26	2,99-3,04			x			
JT-S1 - 27	2,96-2,99	silt with organic matter	x				
JT-S1 - 28	2,94-2,96	sand		x			
JT-S1 - 29	2,89-2,94	peat with silty interbeds	x		x		
JT-S1 - 30	2,84-2,89	alternating bedding of silt, sand; with organic matter		x			
JT-S1 - 31	2,79-2,84	alternating bedding of peat, silt	x				
JT-S1 - 32	2,76-2,79			x	x		
JT-S1 - 33	2,71-2,76	peat with silty interbeds	x				

Table A4-3: continuation

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
JT-S1 - 34	2,66-2,71			x	x		
JT-S1 - 35	2,61-2,66	alternating bedding of silt,sand; with organic matter	x				
JT-S1 - 36	2,56-2,61			x			
JT-S1 - 37	2,51-2,56	silt	x				
JT-S1 - 38	2,46-2,51			x			
JT-S1 - 39	2,41-2,46		x				
JT-S1 - 40	2,36-2,41			x			
JT-S1 - 41	2,31-2,36		x				
JT-S1 - 42	2,26-2,31			x			
JT-S1 - 43	2,21-2,26	silt with organic matter	x		x		
JT-S1 - 44	2,16-2,21	silt		x			
JT-S1 - 45	2,11-2,16	silt with organic matter	x				
JT-S1 - 46	2,06-2,11	alternating bedding of peat, silt		x	x		
JT-S1 - 47	2,01-2,06		x				
JT-S1 - 48	1,96-2,01			x	x		
JT-S1 - 49	1,91-1,96		x				
JT-S1 - 50	1,86-1,91			x	x		
JT-S1 - 52	1,65-1,70	peat with silty interbeds	x				
JT-S1 - 53	1,60-1,65		x	x	x	x	
JT-S1 - 54	1,55-1,60		x				
JT-S1 - 55	1,50-1,55			x	x		
JT-S1 - 56	1,45-1,50	peat	x				
JT-S1 - 57	1,40-1,45			x	x		
JT-S1 - 58	1,35-1,40		x				
JT-S1 - 59	1,30-1,35			x	x		
JT-S1 - 60	1,25-1,30		x				
JT-S1 - 61	1,20-1,25			x	x		
JT-S1 - 62	1,15-1,20		x				
JT-S1 - 63	1,10-1,15			x	x		
JT-S1 - 64	1,05-1,10		x				
JT-S1 - 65	1,00-1,05			x	x		
JT-S1 - 66	0,95-1,00		x				
JT-S1 - 67	0,90-0,95			x	x		
JT-S1 - 68	0,85-0,90		x				
JT-S1 - 69	0,80-0,85			x	x		
JT-S1 - 70	0,75-0,80		x				
JT-S1 - 71	0,70-0,75			x	x		

Table A4-3: continuation

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
JT-S1 - 72	0,65-0,70		x				
JT-S1 - 73	0,60-0,65			x	x		
JT-S1 - 74	0,55-0,60		x				
JT-S1 - 75	0,50-0,55			x	x		
JT-S1 - 76	0,45-0,50	alternating bedding of peat, silt	x				
JT-S1 - 77	0,40-0,45			x	x		
JT-S1 - 78	0,35-0,40		x				
JT-S1 - 79	0,30-0,35			x	x		
JT-S1 - 80	0,25-0,30	loam with plant remains	x				
JT-S1 - 81	0,20-0,25			x	x		
JT-S1 - 82	0,15-0,20	sandy loam with plant remains	x				
JT-S1 - 83	0,10-0,15			x			
JT-S1 - 84	0,05-0,10	soil	x				
JT-S1 - 85	0,00-0,05			x			
JT-S1 - 86	0,00-0,01	vegetation cover	x				

Study site YDK-C1: Central part of Yugus-Jie-Kyuele Lake (72° 51' 04" N, 125° 49' 07"E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
YDK-C1-1	0,00-0,01	clayey silt with organic matter					x
YDK-C1-2	0,01-0,02						x
YDK-C1-3	0,02-0,03						x
YDK-C1-4	0,03-0,04						x
YDK-C1-5	0,04-0,05						x
YDK-C1-6	0,05-0,06						x
YDK-C1-7	0,06-0,07						x
YDK-C1-8	0,07-0,08						x
YDK-C1-9	0,08-0,09						x
YDK-C1-10	0,09-0,10						x

Study site YDK-C2: Central part of Yugus-Jie-Kyuele Lake (72° 51' 04" N, 125° 49' 07"E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
YDK-C2-1	0,37-0,35	clayey silt with organic matter				x	
YDK-C2-2	0,35-0,33		x	x			
YDK-C2-3	0,33-0,31		x	x			
YDK-C2-4	0,31-0,29		x	x			
YDK-C2-5	0,29-0,27		x	x			
YDK-C2-6	0,27-0,25		x	x			
YDK-C2-7	0,25-0,23		x	x		x	

Table A4-3: continuation

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
YDK-C2-8	0,23-0,21		x	x			
YDK-C2-9	0,21-0,19	clayey silt with sand	x	x			
YDK-C2-10	0,19-0,18		x	x			
YDK-C2-11	0,18-0,16	sand	x	x			
YDK-C2-12	0,16-0,14	clayey silt with sand	x	x			
YDK-C2-13	0,14-0,12	clayey silt with organic matter	x	x			
YDK-C2-14	0,12-0,10		x	x		x	
YDK-C2-15	0,10-0,08		x	x			
YDK-C2-16	0,08-0,06		x	x			
YDK-C2-17	0,06-0,04		x	x			
YDK-C2-18	0,04-0,02		x	x			
YDK-C2-19	0,02-0,00		x	x			

Study site YDK-S2: North-east coast of Yugus-Jie-Kyuele Lake (72°51' 14" N, 125°50' 22" E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
YDK-S2-1	3,06-3,01	sand	x	x			
YDK-S2-2	3,01-2,96		x				
YDK-S2-3	2,96-2,91	sand with plant remains		x			
YDK-S2-4	2,91-2,86		x				
YDK-S2-5	2,86-2,81			x			
YDK-S2-6	2,81-2,76		x				
YDK-S2-7	2,76-2,71			x			
YDK-S2-8	2,71-2,66		x				
YDK-S2-9	2,66-2,61			x			
YDK-S2-10	2,61-2,56		x				
YDK-S2-11	2,56-2,50	peat	x	x		x	
YDK-S2-12	2,50-2,45	peat with sand	x	x			
YDK-S2-13	2,45-2,40	alternating bedding of peat, sand	x	x			
YDK-S2-14	2,40-2,.35	peat with sand	x	x			
YDK-S2-15	2,35-2,30	alternating bedding of peat, sand		x			
YDK-S2-16	2,30-2,25		x				
YDK-S2-17	2,25-2,20	sand with plant remains		x			
YDK-S2-18	2,20-2,15	alternating bedding of peat, sand	x				
YDK-S2-19	2,15-2,10			x			
YDK-S2-20	2,10-2,05		x				
YDK-S2-21	2,05-2,00			x			

Table A4-3: continuation

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
YDK-S2-22	2,00-1,95	sand	x				
YDK-S2-23	1,95-1,90			x			
YDK-S2-24	0,72-0,74	alternating bedding of peat, sand				x	

Study site MTC-S3: Terrace of the Malaya Tumatskaya Channel (72° 51' 58" N, 125° 55' 08" E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
MTC-S3-1	6,05-6,35	wood				x	
MTC-S3-2	1,20-1,25	peat				x	
MTC-S3-3	5,97-6,15	wood				x	
MTC-S3-4	1,65-1,73	wood				x	

Study site KK-S4: North coast of Kyuejya-Kyuele Lake (72° 54' 12" N, 125° 51' 30' E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
KK-S4-1	0,68-0,73	peat				x	

Study site MTC-S5: Terrace of the Malaya Tumatskaya Channel (72° 57' 09" N, 125° 55' 06" E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
MTC-S5-1	2,05-2,10	peat	x	x			
MTC-S5-2	2,00-2,05			x	x		
MTC-S5-3	1,95-2,00		x				
MTC-S5-4	1,90-1,95			x	x		
MTC-S5-5	1,85-1,90		x				
MTC-S5-6	1,80-1,85		x	x	x	x	
MTC-S5-7	1,75-1,80			x			
MTC-S5-8	1,70-1,75		x				
MTC-S5-9	1,65-1,70			x			
MTC-S5-10	1,60-1,65	alternating bedding of peat, silt, sand	x				
MTC-S5-11	1,55-1,60	peat	x				
MTC-S5-12	1,50-1,55	peat with sandy inter-beddeds		x	x		
MTC-S5-13	1,45-1,50	alternating bedding of peat, sand	x				
MTC-S5-14	1,40-1,45	sand with plant remains		x			
MTC-S5-15	1,35-1,40	peat	x				
MTC-S5-16	1,30-1,35			x			
MTC-S5-17	1,25-1,30		x	x	x	x	
MTC-S5-18	1,20-1,25		x				

Table A4-3: continuation

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
MTC-S5-19	1,15-1,20			x	x		
MTC-S5-20	1,10-1,15		x				
MTC-S5-21	1,05-1,10			x	x		
MTC-S5-22	1,00-1,05		x				
MTC-S5-23	0,95-1,00			x	x		
MTC-S5-24	0,90-0,95		x				
MTC-S5-25	0,85-0,90			x	x		
MTC-S5-26	0,80-0,85		x				
MTC-S5-27	0,75-0,80	peat with silty interbeddeds		x	x		
MTC-S5-28	0,70-0,75	peat	x				
MTC-S5-29	0,65-0,70			x	x	x	
MTC-S5-30	0,60-0,65	alternating bedding of peat, sand	x		x		
MTC-S5-31	0,58-0,60	peat with sandy inter-beddeds		x			
MTC-S5-32	0,55-0,58	peat	x				
MTC-S5-33	0,50-0,55	peat with sandy inter-beddeds		x			
MTC-S5-34	0,45-0,50		x	x	x	x	
MTC-S5-35	0,40-0,45			x			
MTC-S5-36	0,35-0,40		x		x		
MTC-S5-37	0,30-0,35	peat		x			
MTC-S5-38	0,25-0,30	peat with sandy inter-beddeds	x				
MTC-S5-39	0,20-0,25	alternating bedding of peat, silt, sand		x	x		
MTC-S5-40	0,15-0,20	sandy loam with plant remains	x				
MTC-S5-41	3,65-3,70	sand		x			
MTC-S5-42	3,60-3,65		x				
MTC-S5-43	3,55-3,60			x			
MTC-S5-44	3,50-3,55	alternating bedding of peat, silt, sand	x				
MTC-S5-45	3,45-3,50			x	x		
MTC-S5-46	3,40-3,45		x				
MTC-S5-47	3,35-3,40	sand with organic matter		x			
MTC-S5-48	3,30-3,35	sand	x				
MTC-S5-49	3,13-3,18	peat		x	x		
MTC-S5-50	3,08-3,13	peat with sandy interbedded	x				
MTC-S5-51	3,03-3,08	alternating bedding of peat, sand		x			

Table A4-3: continuation

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
MTC-S5-52	2,98-3,03	peat	x	x	x	x	
MTC-S5-53	2,93-2,98	alternating bedding of peat, sand		x			
MTC-S5-54	2,88-2,93	peat	x				
MTC-S5-55	2,83-2,88			x	x		
MTC-S5-56	2,78-2,83		x				
MTC-S5-57	2,60-2,65			x	x		
MTC-S5-58	2,55-2,60		x				
MTC-S5-59	2,50-2,55			x	x		
MTC-S5-60	2,45-2,50	alternating bedding of peat, sand	x				
MTC-S5-61	2,40-2,45	sand with organic matter		x			
MTC-S5-62	2,35-2,40		x				
MTC-S5-63	2,30-2,35			x			
MTC-S5-64	2,25-2,30		x				
MTC-S5-65	2,20-2,25			x			
MTC-S5-66	2,15-2,20	peat with sandy inter-beddeds	x				
MTC-S5-67	2,10-2,15			x	x		

Study site OOK-C1: Central part of Ogo-Olbyut-Kyuele Lake (73° 14' 30" N, 126° 11' 00" E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
OOK-C1-1	0,80-0,82	sandy silt with organic matter	x	x			
OOK-C1-2	0,78-0,80		x	x		x	
OOK-C1-3	0,76-0,78		x	x			
OOK-C1-4	0,74-0,76		x	x			
OOK-C1-5	0,72-0,74		x	x			
OOK-C1-6	0,70-0,72		x	x			
OOK-C1-7	0,68-0,70		x	x			
OOK-C1-8	0,66-0,68		x	x			
OOK-C1-9	0,64-0,66		x	x			
OOK-C1-10	0,62-0,64		x	x			
OOK-C1-11	0,60-0,62		x	x			
OOK-C1-12	0,58-0,60		x	x			
OOK-C1-13	0,56-0,58		x	x			
OOK-C1-14	0,54-0,56		x	x			
OOK-C1-15	0,52-0,54		x	x		x	
OOK-C1-16	0,50-0,52		x	x			
OOK-C1-17	0,48-0,50		x	x			

Table A4-3: continuation

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
OOK-C1-18	0,46-0,48		x	x			
OOK-C1-19	0,44-0,46		x	x			
OOK-C1-20	0,42-0,44		x	x			
OOK-C1-21	0,40-0,42		x	x			
OOK-C1-22	0,38-0,40		x	x			
OOK-C1-23	0,36-0,38		x	x			
OOK-C1-24	0,34-0,36		x	x			
OOK-C1-25	0,32-0,34		x	x			
OOK-C1-26	0,30-0,32		x	x			
OOK-C1-27	0,28-0,30		x	x			
OOK-C1-28	0,26-0,28		x	x			
OOK-C1-29	0,24-0,26	silt with organic matter and plant remains	x	x		x	
OOK-C1-30	0,22-0,24	sandy silt with organic matter	x	x			
OOK-C1-31	0,20-0,22		x	x			
OOK-C1-32	0,18-0,20		x	x			
OOK-C1-33	0,16-0,18		x	x			
OOK-C1-34	0,14-0,16		x	x			
OOK-C1-35	0,12-0,14		x	x			
OOK-C1-36	0,10-0,12		x	x			
OOK-C1-37	0,08-0,10		x	x			
OOK-C1-38	0,06-0,08		x	x			
OOK-C1-39	0,04-0,06		x	x			
OOK-C1-40	0,02-0,04		x	x			
OOK-C1-41	0,00-0,02		x	x			

Study site SKK-C1: Central part of Kyuchuk-Kyuele Lake, Sagastyr Island (73° 23' 05" N, 126° 35' 20" E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
SKK-C1-1	0,00-0,01	silt with detritus					x
SKK-C1-2	0,01-0,02						x
SKK-C1-3	0,02-0,03						x
SKK-C1-4	0,03-0,04						x
SKK-C1-5	0,04-0,05						x
SKK-C1-6	0,05-0,06						x
SKK-C1-7	0,06-0,07						x
SKK-C1-8	0,07-0,08						x
SKK-C1-9	0,08-0,09						x
SKK-C1-10	0,09-0,10						x

Table A4-3: continuation

Study site SKK-C2: Central part of Kyuchuk-Kyuele Lake, Sagastyr Island (73° 23' 05" N, 126° 35' 20" E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
SKK-C2-1	0,29-0,33	silt with detritus	x	x			
SKK-C2-2	0,27-0,29		x				
SKK-C2-3	0,25-0,27		x	x			
SKK-C2-4	0,23-0,25		x				
SKK-C2-5	0,21-0,23		x	x			
SKK-C2-6	0,19-0,21		x				
SKK-C2-7	0,17-0,19		x	x			
SKK-C2-8	0,15-0,17		x				
SKK-C2-9	0,13-0,15		x	x			
SKK-C2-10	0,11-0,13		x				
SKK-C2-11	0,09-0,11		x	x			
SKK-C2-12	0,07-0,09		x				
SKK-C2-13	0,05-0,07		x	x			
SKK-C2-14	0,03-0,05		x				
SKK-C2-15	0,01-0,03		x	x			
SKK-C2-16	0,00-0,01		x				

Study site S-S6: South coast of Sagastyr Island (73° 22' 17" N, 126° 33' 50" E)

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
S-S6-1	1,15-1,20	alternating bedding of peat, silt	x				
S-S6-2	1,10-1,15			x			
S-S6-3	1,05-1,10		x	x	x	x	
S-S6-4	1,00-1,05				x		
S-S6-5	0,90-0,95		x		x		
S-S6-6	0,85-0,90			x			
S-S6-7	0,80-0,85	peat	x	x	x	x	
S-S6-8	0,75-0,80			x	x		
S-S6-9	0,70-0,75	alternating bedding of peat, silt	x				
S-S6-10	0,65-0,70			x	x		
S-S6-11	0,60-0,65	peat	x				
S-S6-12	0,55-0,60			x	x		
S-S6-13	0,50-0,55		x				
S-S6-14	0,45-0,50			x	x		
S-S6-15	0,40-0,45		x				
S-S6-16	0,35-0,40			x	x		
S-S6-17	0,30-0,35		x				

Table A4-3: continuation

Sample no	Depth (m)	Sediment	PA	DA	PR	D	IA
S-S6-18	0,25-0,30			x	x		
S-S6-19	0,20-0,25	alternating bedding of peat, silt	x				
S-S6-20	0,15-0,20			x	x		
S-S6-21	0,10-0,15		x				
S-S6-22	0,05-0,10			x	x		
S-S6-23	0,02-0,05		x				
S-S6-24	0,00-0,02	vegetation cover	x				

PA - pollen analysis; DA - diatom analysis; PR - analysis of plant remains; D - dating; IA - isotopic analysis (Pu-239, 240).

Table A4-4: List of plant species found in the northern Lena River delta (abbreviations see end of table).

Plant species	YJ	L-1	YJK	KKL	L-2
Equisetaceae					
Equisetum.arvense ssp. boreale			x		x
Graminaceae					
Arctagrostis latifolia			x	x	x
Deshampsia caespitosa ssp. borealis				x	x
Dupontia fisheri				x	x
Hierochloe pauciflora			x		x
Koeleria asiatica	x	x			x
Poa arctica	x	x	x		x
Cyperaceae					
Carex aquatilis ssp. stans	x	x			x
Eriophorum polystachion	x	x			
Eriophorum vaginatum	x	x			
Juncaceae					
Juncus biglumis					x
Luzula confusa			x	x	
Liliaceae					
Lloydia serotina	x				
Salicaceae					
Salix glauca	x	x			
Salix nummularia	x		x	x	
Salix pulchra			x		
Salix reptans	x	x			x
Betulaceae					
Betula nana ssp. exilis				x	
Polygonaceae					
Polygonum bistorta ssp. ellipticum	x	x		x	
Polygonum laxmanna			x	x	
Polygonum tripterocarpum	x	x			
Polugonum viviparum			x	x	x
Rumex graminifolius			x		
Caryophyllaceae					
Cerastium beeringianum				x	
Melandrium apetalum			x	x	
Minuartia arctica			x		
Minuartia macrocarpa			x		
Stellaria ciliatosepala					x
Ranunculaceae					

Table A4-4: continuation

Plant species	YJ	L-1	YJK	KKL	L-2
Caltha arctica	x	x			
Delphinium brachycentrum	x	x			
Ranunculus appinis	x	x			
Ranunculus pygmaeus				x	x
Papaveraceae					
Papaver angustifolium	x	x			
Papaver pulvinatum	x	x	x	x	x
Fumaraceae					
Corydalis arctica				x	
Cruciferae					
Cardamine pratensis	x	x			
Draba borealis	x	x			
Draba hirta	x	x			
Draba juvenilis	x	x			
Draba pilosa			x		
Parrya nudicaulis	x	x			
Saxifragaceae					
Chrysosplenium tetrandrum	x	x		x	
Saxifraga cernna	x	x			
Saxifraga foliolosa			x		x
Saxifraga hirculus	x	x			x
Saxifraga nelsoniona	x	x			x
Rosaceae					
Dryas octopetala	x	x	x	x	x
Rubus chamaemorus				x	
Leguminosae					
Astragalus alpinus	x				
Astragalus umbellatus	x				
Diapensiaceae					
Diapensia obovata			x		
Pyrolaceae					
Pyrola minor	x				
Ericaceae					
Cassiope tetragona			x	x	
Ledum palustre ssp. decumbens				x	
Vaccinium vitis-idaea ssp. minus				x	
Plumbaginaceae					
Armeria maritima			x	x	x
Polemoniaceae					

Table A4-4: continuation

Plant species	YJ	L-1	YJK	KKL	L-2
Polemonium boreale	x	x			
Boraginaceae					
Myosotis asiatica	x	x			x
Scrophulariaceae					
Lagotis glauca ssp. minor	x	x			
Pedicularis capitata			x	x	
Pedicularis oederi	x	x			
Pedicularis sudetica ssp. interioroides	x	x			x
Valerianaceae					
Valeriana capitata	x	x			x
Compositae					
Artemisia borealis			x	x	
Artemisia serissima			x	x	
Artemisia tilesii	x	x		x	
Nardosmia frigida	x	x			
Senecio congestus (arcticus)					x
Tanacetum bipinnatum				x	
Taraxacum ceratophorum	x	x			
Mosses					
Calliergon giganteum					x
Sphagnum orientale					x
Tomenthyphum nitens					x

Location of herbarium collects: YJ - Yugus-Jie; L-1, L-2 - pollen trap stations; YJK - region of Yugus-Jie-Kyele Lake; KKL - region of Kyuejya-Kyuele Lake.

5 Paleoclimate Signals of Ice-rich Permafrost

5.1 Introduction

(C. Siegert)

In Northern Siberia large areas of the Arctic coastal lowland are covered by ice-rich permafrost - the "Ice Complex" or "Yedoma". In this unique cryolithogenic formation we can find keys for the reconstruction of the Late Quaternary climate and environment in the Eurasian North, especially in the Laptev Sea region. Despite earlier research many topical problems such as the genesis and the age of this permafrost sequences remain unsolved up to now. But, today there is no doubt, that they are formed in non-glaciated areas. To provide further progress in this question only a well coordinated multidisciplinary research of this unique formation enables to solve the most topical problems.

In summer 1998 a group of 11 scientists from Germany and Russia for the first time carried out such a multidisciplinary research program which included:

- Complex cryolithological studies;
- Research of ground ice to use different isotope and hydrochemical analyses,
- Systematic paleontological research;
- Extensive sampling for age dating;
- Study of modern geocryological processes.

The field work took place in the key location" Mamontovy Khayata" and adjacent areas on the Bykovsky Peninsula. Several previous studies carried out at this area by Russian geocryologists and in the last years also by Japanese researchers, are a good basis for planning our field work and analytical investigations.

5.2 Geological-geomorphological characteristics of the study area

(L. Schirrmeister, C. Siegert, V. Kunitzky and A. Sher)

The Bykovsky Peninsula is situated north-east of the town Tiksi between 71°40' - 71°80' N and 129°- 129°30' E (Figure 5-1). The peninsula is mushroom-like shaped and extends in NNW-SSE-direction 40 km parallel to the mainland in front of the Kharaulakh Ridge. The Bykovsky Peninsula ends at the Bykovsky Channel of the Lena Delta in the north, encloses the Neelov Bay with the west coast, is bordered by the Tiksi Bay in the south and by the Laptev Sea in the east. The mushroom shape is caused by a 5 km wide and 15 km long landstrip. The delta and the mouth of the small river Khorogor rising from the Kharaulakh Ridge west of Tiksi are situated on this landstrip.

The highest areas of the Bykovsky Peninsula lie about 40 m above sea-level.

This original surface, called "Yedoma", is lowered by thermal denudation down to the elevations of 20-25 m, in some areas to 15 m. It was also subjected to thermokarst, thermal erosion, and thermal abrasion at the coast. Resultant topography displays numerous thermokarst depressions (alases), with or without existing lakes in them (the alas bottoms vary in altitude from 2 to 15 m a.s.l.); wide and shallow valleys of surface runoff; and lagoons at the sea shore. The recent picture is completed by numerous small nival niches and single pingos in large alases. The sea coast of the Bykovsky Peninsula is characterized by steep cliffs and wide shallow bars.

The Bykovsky Peninsula and a small island Muostakh SE of it are thought to be a part of a former alluvial plain in the south-east of the Lena Delta (Slagoda 1993). Like the whole Lena Delta Region, the studied area belongs to the Arctic Rift Zone. It is characterised by vertical block tectonic with narrow long horsts, grabens and synclines and a high seismic activity and is described as a denudative fault block covered by younger Cenozoic sediments (Grigoryev et al. 1996). The Bykovsky Peninsula is situated on such a block at the western margin of the Ust'-Lena-Rift (Figure 5-2). Are, Reimnitz and Kolatschek (1998) suggest that tectonic processes still affect the formation of the Lena Delta. Their arguments are the linearity of Lena river branches, the high seismic activities in this region and the zigzag-pattern of the Yedoma areas.

The whole study region is within the zone of continuous permafrost reaching a thickness up to 500-600 m. According to Romanovsky et al. (1997), permafrost expanded to the recent -100 m isobath of the Laptev Sea Shelf during the Late Pleistocene as a result of the shelf exposure due to eustatic lowering of sea level.

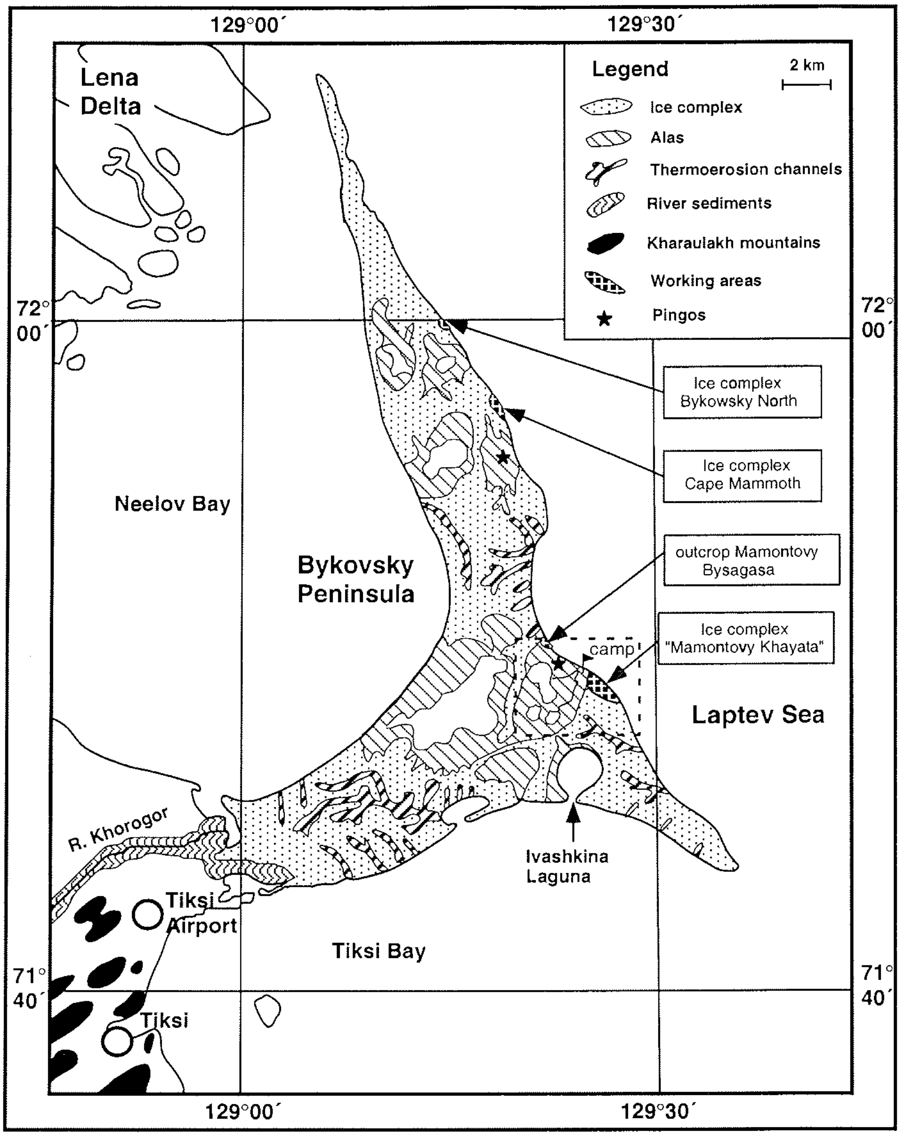

Figure 5-1: Schematic map of the Bykovsky Peninsula.

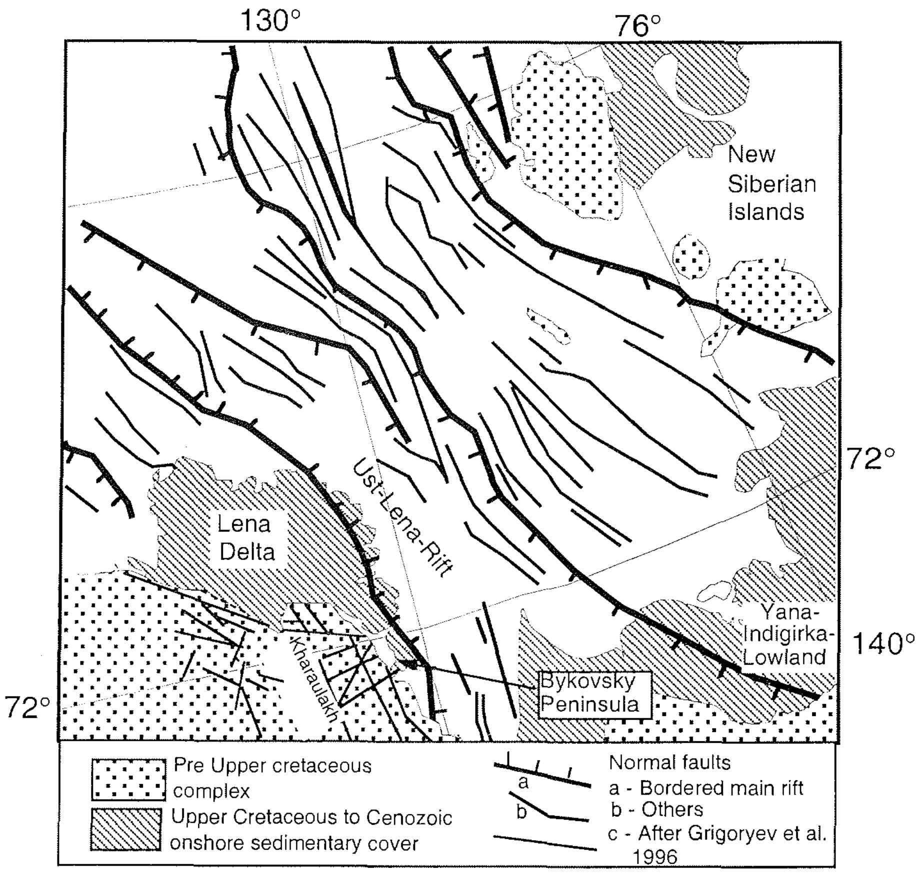

Figure 5-2: Tectonic situation in the Lena Delta area (after Drachev et al.1998 and Grigoryev et al. 1996).

The Yedoma of the Bykovsky Peninsula is built by Ice Complex - a peculiar syncryogenic formation consisting of fine-grained sediments with high content of structure-forming ice and thick polygonal ice wedges. The ice wedges are 5-8 m wide and up to 30-40 m high. The intrapolygonal sediment blocks have absolute ice contents up to 60-80%, while the total ice content in an Ice Complex can be higher than 80%. The sedimentary part of the Ice Complex in the studied area consists mainly of well sorted sandy silt with a relatively homogenous mineralogical composition. Various organic material in sandy silt includes *in situ* grass roots, autochthonous peat lenses, peat "hummocks", plant detritus, insect and plant macrofossils, bones of large and small mammals.

The genesis of the Ice Complex is still being debated. Various concepts have been forwarded to explain the origin of this formation, which is widely distributed in Northeast Siberia (Table 5-1); the most popular being fluvial, eolian, and polygenetic concepts. Particularly for the Bykovsky Peninsula Ice Complex, nowadays researchers interpreted it as cryogenic-eolian sediments (Tomirdiaro and Chernin'kiy 1987), as "peculiar slope deposits accumulating mostly due to the meltwater runoff from the permanent snow patches" (Kunitzky 1989, p.98), or as floodplain and proluvial-slope sediments (Slagoda 1991).

Table 5-1: Summary of various interpretations of the origin and age of the Ice Complex in the Laptev Sea area.

Origin	Age	Citation	Area studied
Buried remnants of glaciers		Toll, 1895, Vollosowich, 1914, etc.	Lyakhovsky Island, Coastal Lowland
River floodplain sediments	Middle Pleistocene (second half)	Popov, 1953, 1969, etc-	Lower Yana R.
Giant icings with mud flow channels	Late Pleistocene	Gusev, 1958	Bykovsky, Coastal Lowland
Fluvial sediments of meandering rivers	(Middle)-Late Pleistocene	Katasonov, 1975 (Vtyurin et al., 1957), Romanovsky, 1958	Coastal Lowland, Lower Yana R., Lyakhovsky Island
Sediments of fluvial-lacustrine plain	Kargin interglacial	Strelkov, 1960	Coastal Lowland
Fluvial (shallow channel facies)	Vorontsov Formation - Middle Pleistocene (Tazov)	Lavrushin, 1962	Lower Indigirka R.
Lacustrine-palustrine sediments	Oyagoss Formation - (Middle)-Late Pleistocene	Kayalaynen and Kulakov, 1966	Coastal Lowland
Fluvial and fluvial-lacustrine sediments	Oyagoss Formation (Zyryan)	Ivanov, 1972	Coastal Lowland
Cryogenic-eolian (loess-ice) formation	Late Pleistocene (Zyryan and Sartan ice complexes separated by Kargin peat)	Tomirdiaro et al, 1984 etc.	Bykovsky, Oyagoss Yar, etc.
Deposits of basins dammed by the shelf glacier, on-glacial stream sediments	Late Pleistocene	Grosswald, 1983, 1998, etc)	incl. Bykovsky

Table 5-1: continuation

Origin	Age	Citation	Area studied
Polygenetic origin (fluvial, slope, eolian, etc)	Yedoma Formation - Yedoma Superhorizon, subdivided into Oyagoss (=Zyryan), Molotkov (=Kargin) and Sartan Horizons	Unified Regional Stratigraphic Chart for the Quaternary of the Yana-Kolyma Lowland (Sher et al., 1987)	Coastal Lowland
"Extranivits" (sediments formed by water running from snow patches)	Late Pleistocene	Kunitsky, 1989	Bykovsky
Floodplain sediments, proluvial slope sediments	Lower Ice complex (Middle-Late Pleistocene) and Upper Ice Complex (Sartan)	Slagoda, 1991, 1993	Bykovsky
Sediments of river delta and "swamp", dammed by the shelf ice-sheet	Kargin Interglacial	Nagaoka, 1994; Nagaoka et al., 1995	Bykovsky, Lyakhov Island, Oyagoss Yar

There is more general agreement concerning the age of Ice Complex at the Bykovsky Peninsula. Radiocarbon dates, rather numerous in the middle and upper parts of the section (see section 5.6), allow different researchers to unanimously refer the whole sequence to the Late Pleistocene. There are different opinions, however, on the detailed stratification of the sequence and the recognition of particular units within it (Figure 5-3). Tomirdiaro and Chernin'kiy (1987) distinguished the lower and the upper parts of the Bykovsky Ice Complex, ascribed to the Zyryan ($Q_{III}{}^2$) and Sartan ($Q_{III}{}^4$) stages respectively; these two units are separated by the peat horizon observed at 16-20 m a.s.l., which is ascribed to the Kargin "warm stage" ($Q_{III}{}^3$) (Tomirdiaro et al., 1984). Kunitzky (1989) considered the whole Ice Complex sequence of the Bykovsky Peninsula as a single unit (Razdelniy Layers), dated from the Late Pleistocene (Q_{III}). This author seemingly gives no special stratigraphic importance to any peat layer within the section, describing them as separate lenses in the interval of 15-20 m a.s.l.. Slagoda (1993) recognised the Lower and Upper Ice Complex and showed that they differed essentially in the lithological and mineralogical composition, and that they are of different origin. These two units are separated by sediments of lacustrine and bog origin, including autochthonous peat lenses up to 1 km long. She demonstrated that these peat lenses vary in thickness and follow an uneven topography of the roof of the Lower Ice Complex, so they can have different altitude at various stations. Slagoda (1993) considers this intermediate unit (Horizon III) as a lower member of the Upper Ice Complex. According to her correlations, numerous radiocarbon dates from

Horizon III vary from infinite (>45,000) to 22,000 y BP; consequently, the whole Upper Ice Complex is dated as Kargin-Sartan (Q_{III}^{3-4}). The Lower Ice Complex is supposed to be of the Middle-Late Pleistocene age (including Zyryan) (Q_{II}-Q_{III}^{2}). Japanese scientists (Fukuda 1994, Nagaoka et al. 1995) refer the whole succession of Ice Complex on the Bykovsky Peninsula to the Kargin Interstadial.

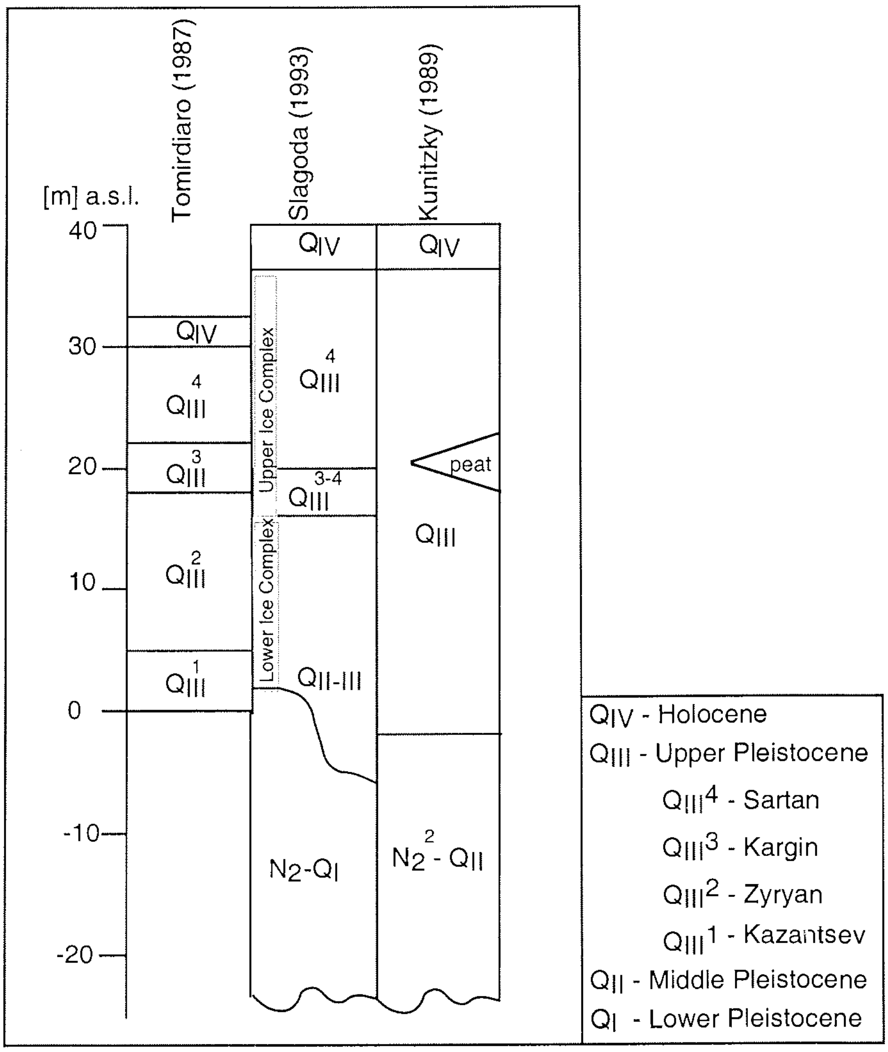

Figure 5-3: Comparison of stratigraphic classification of Quaternary deposits of the Bykovsky Peninsula.

There is no definite evidence concerning the problem how the Pleistocene climatic fluctuations were represented in the Bykovsky the Ice Complex. Some researchers believe that syncryogenic sequences of Ice Complex were formed during the strong cooling periods ("cryochrons"), while the separated peat horizons reflect "thermochrons" - the periods of warmer climate and more or less pronounced permafrost degradation, resulted in thermokarst and accumulation of alas deposits (Tomirdiaro 1987). This view is most generally accepted for the Ice Complex of the whole coastal lowlands of Northern Yakutia. However, Kunitsky (1989) argues that the peat layers in the Bykovsky Ice Complex do not reflect any climate warming, and that the continuous accumulation of the Ice Complex went on during the Quaternary under severe climatic conditions without any prominent warmings). The Japanese scientists believe that the formation of the Ice Complex took place during the Kargin Interstadial under very unstable climatic conditions (Fukuda, 1994), colder than the present, but not as cold as the Sartan ones, when the Ice Complex accumulation stopped (Nagaoka et al., 1995).

There is some disagreement concerning the age and occurrence of the sediments underlying the Ice Complex on the Bykovsky Peninsula. Kunitzky (1989) believes that everywhere on the Peninsula and on the Muostakh Island the base of the Ice Complex (Razdelny Layers) lies below the sea level, where it overlies the sands and silts of the Muostakh Series. The latter is known from the boreholes only, and is supposed to date from the Eopleistocene (=Early Pleistocene of the European scales) to the Middle Pleistocene. According to Slagoda (1993), the Lower Ice Complex is underlain by cross-bedded sands and gravels of the Pliocene - Early Pleistocene age, which are exposed at some stations on the southern coast of the peninsula (Razdelny Cape) up to 15-18 m a.s.l.

This review shows that despite the large scope of previous studies on the Bykovsky Peninsula, there is a lack of agreement between the researchers, and the most important questions of the Late Quaternary environmental history remain unsolved.

5.3 Modern geological processes on Bykovsky Peninsula

(V. Tumskoy and V. Kunitzky)

All modern geological processes in the area are related to a cryogenic group. The study of their distribution and development allows to reconstruct more substantially a history of accumulation and transformation of syncryogenic frozen deposits on the Bykovsky Peninsula. The main modern cryogenic processes on the investigated territory are thermal abrasion, thermal erosion, thermal denudation, frost cracking, solifluction, frost heave and to a less degree - thermokarst. The development of these processes is caused by the following conditions:

- low mean annual temperature of permafrost (-11°C) and small thickness of the active layer (0.2-0.5 m);
- high ice content of the Pleistocene deposits of Ice Complex, occupying more than half of the area of the peninsula;
- wide distribution of slopes linked to numerous alas depressions, separating the preserved islands of Ice Complex and creating conditions for development of the cryogenic slope processes;
- large extension of the coastal line.

The processes of thermal abrasion develop along a significant part of Bykovsky Peninsula coasts and are linked with the thermal and mechanical influence of sea water on frozen deposits. They result in the formation of coastal outcrops of Ice Complex (Mamontovy Khayata, Cape Mamont, Cape Razdelny) and alas deposits (Mamontovy Bysagasa). The character of destruction of the Ice Complex coastal outcrops is determined by relation between the rates of thermal abrasion and thermal denudation and is accompanied by the formation of wide bars along the coast. In some alases, already partially destroyed by thermal abrasion, the block destruction of coast occurs following the network of Holocene ice wedges. Locally thermal abrasion develops along the coasts of alas lakes.

Thermal denudation is a process of thawing of frozen deposits under the influence of rather warm air. On the Bykovsky Peninsula it takes place mostly on large coastal outcrops. In result thermal denudation there is a thawing of frost deposits in the outcrops. Thawed material flows down to the lower levels, it accumulates there and in result the outcrops become less steep. The joint influence of thermal abrasion and thermal denudation on coastal outcrop results in a recession of their upper edge. The measured rate of Mamontovy Khayata edge recession is 4 m/year (Grigoryev, 1993).

Processes of Ice Complex denudation are activated by solifluction and thermal erosion. On the Bykovsky Peninsula solifluction is active practically everywhere on the alas depression slopes and in the areas of extensive (up to hundreds of meters) scours developing in the Ice Complex deposits. Solifluction shows itself in topography as extended steps (shoulders) up to 0.5 m high found near the base of slopes, which reduce general slope steepness. Combined with thermal erosion, solifluction leads to the formation of low hillocks in the upper parts of slopes. In some places fast solifluction develops on the slopes of alases and channels, connecting alases with the sea. Thermal erosion is observed at the openings of some scours and channels, connecting alas depressions. In the scours, thermal erosion creates deep (up to 5-6 m) ravines and occasionally thermal wells up to 8 m deep. The basal parts of the scours, related to thermal erosion, are separated from the upper (source) parts by a shoulder 2-3 m high, often with a waterfall. Thermal erosion ravines are related to the ice wedges of Pleistocene and Holocene age and follow their outlines in plan.

Thermokarst processes also contribute to the destruction of Ice Complex on Bykovsky Peninsula, but not as much as during the Holocene optimum time. Extensive alas depressions, reaching 4 km in diameter and 20-30 m in depth are evidently the witnesses of ancient lake thermokarst of that time. Residual thermokarst lakes inside them occupy usually more than a half of the alas area and are less than 2 m deep. Recently formed thermokarst lakes have a rather limited distribution. They are found on the Yedoma surface and are only up to 200 m in diameter; their measured depth does not exceed 4 m. Their development is probably limited by modern cold climate and active thermal erosion. Measurement of water temperature in one of these thermokarst lakes on the Yedoma surface (the depth is 3.9 m) has shown that near the lake bottom the water is rather warm due to wind agitating (Table 5-2). That promotes intensive thawing of the frozen sediment beneath the lake and fast subsidence of the lake floor.

Table 5-2: Measurements of water temperature in the Mammoth Eye lake.

Depth, m / Date	Temperature [°C]			
	06.08.98	08.08.98	11.08.98	12.08.98
0.3	14.4	11.9	9.0	8.1
0.6	14.2	11.7	8.8	7.9
0.9	14.3	11.8	8.8	7.9
1.2	14.4	11.8	8.9	8.0
1.5	14.4	11.8	8.8	8.0
2.0	14.2	11.7	8.8	7.9
2.5	14.2	11.8	8.8	7.9
3.0	11.7	11.8	8.8	8.0
3.5	11.4	11.8	8.8	7.9
Max. air temperature, [°C]	23.9	17.2	14.2	13.1

Frost cracking of ground occurs on all relatively horizontal elements of relief. On the bottom of alases it results in the development of distinct low-centre polygons related to the growth of modern ice wedges. The polygons have irregular four- or five-cornered form and transverse size from 10×10 to 30×30 m. Relative elevations within the polygons is up to 0.2-0.3 m. No low-centre polygons were observed on the Yedoma surface. Clay patches up to 0.5 m in diameter appear on that surface due to nonuniform freezing of tussocky tundra soil.

This complex of ancient and modern cryogenic processes is responsible for the Bykovsky Peninsula topography and remains a major factor of its current development.

5.4 Ground ice studies

(H. Meyer, A. Dereviagin and I. Syromyatnikov)

5.4.1 Study subjects, their characteristics

Ice Complex includes two main types of ground ice: segregated ice and ice wedges. The source of ice-wedge ice formation is snowmelt water; the source of segregated ice formation is suprapermafrost ground water of active layer. Ground ice can be used as an excellent climate archive. Most promising ground ice archives for paleoclimate reconstruction are huge syngenetic ice wedges, which are typical for our working area. Ice wedges form principally by frost cracking and freezing of melt water of the previous years winter precipitation. Thus the stable isotope composition of ice wedges approximately reflect annual winter temperatures. Thermal contraction of the ground in winter leads to the formation of polygonal ice wedge systems. In our working area, where the permafrost temperature is -12°C, melt water freezes immediately and volume expansion takes place. In spring and summer, the upper layer of permafrost, the active layer thaws, and only frost cracks entering the permafrost will be conserved.

A periodically freezing and thawing leads to the following effects: (1) ice wedges contain a chronological sequence getting older from the middle towards the edges of the ice wedge, (2) the sediment on both sides of the ice wedge is pushed towards the surface and (3) walls form at the surface on both sides of the frost crack. Syngenetic ice wedges are formed during the accumulation of sediments in flood plains, deltas, shallow lakes or slope deposits, whereas epigenetic ice wedges are formed after sedimentation at stable surfaces or in Prequaternary deposits. According to Kunitsky (1989), the sampled ice wedges were attributed to the Weichselian and Holocene times.

Intrapolygonal ponds with sedge growth are located between modern ice wedges. These ponds are sinks for sediment, organic matter, precipitation and melt water. In summer, when the active layer thaws, soil is saturated with suprapermafrost water of different origin (melt water, summer precipitation etc.). Sediment accumulation or middle-term climatic changes lead to upward movement of the lower boundary of the active layer. The lower part of the active layer is transferred into perennially frozen sediments with segregated ice. The latter provides information about the freezing conditions. For example, massive ice belts characterise a relatively stable surface and a stable position of the boundary active layer/permafrost.

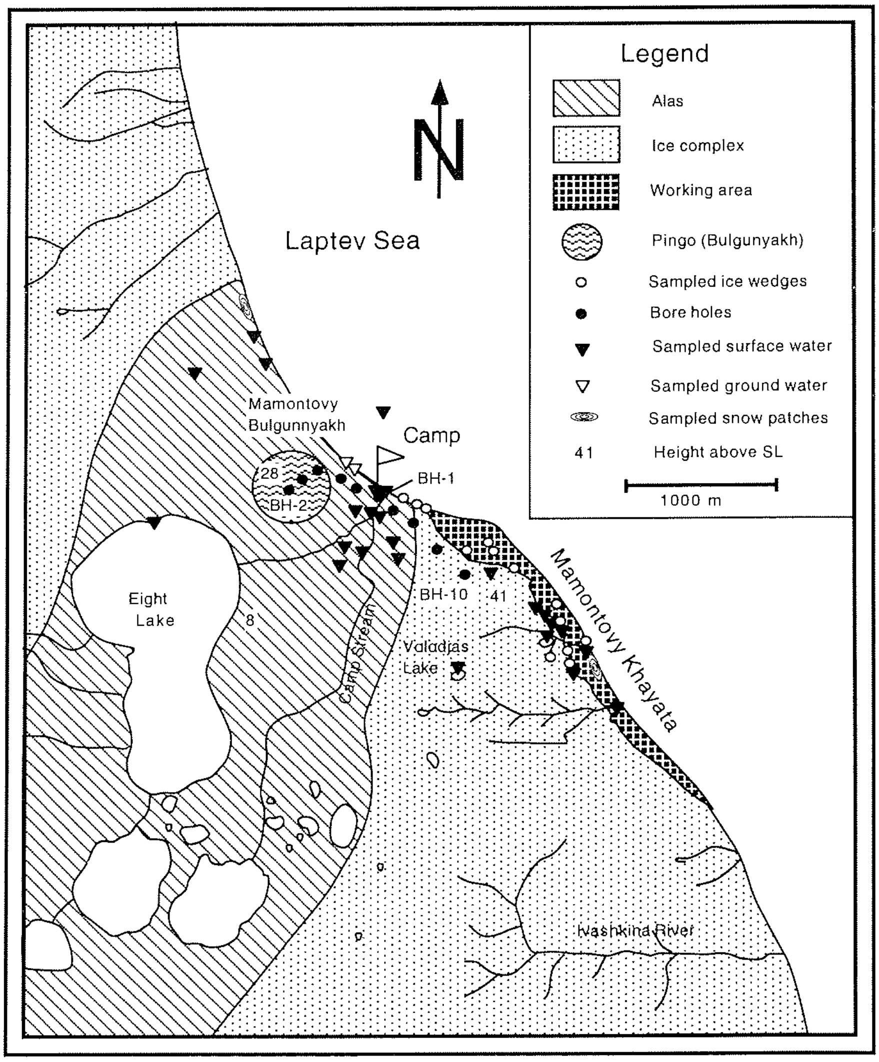

Figure 5-4: Working area on Bykovsky Peninsula with the sampling sites for isotope studies.

In the working area, three cryolithogenic facies with different types of ground ice can be distinguished (Figure5-9a-c; 5-10). The main study was carried out in the Late Pleistocene Ice Complex "Mamontovy Khayata". In addition, two younger facies (likely of Holocene age) were investigated: alas deposits located to the north of the Ice Complex and sandy, deluvial-proluvial sediments which overlie the Ice Complex in the southern part. These facies contain different age generations of ground ice. All facies imply massive, mostly syngenetic ice wedge growth and fine dispersed segregated ice. Additionally, in some parts of the section active ice wedges were observed.

5.4.2 Methods

In order to reconstruct paleoclimatic changes and paleoenvironmental conditions of Northern Siberia, sampling for stable isotope method, ^{10}Be, tritium and hydrochemistry (pH, electrical conductivity, anions, cations) were carried out for ice wedges and segregated ice. Samples were collected simultaneously for all types of analysis. During field work, 751 samples of surface water and various types of ground ice were taken (Table A5-1, appendix). Samples from different modern surface waters (small streams, thermokarst lakes, ice wedge ponds, Laptev Sea) and precipitation (rain, snow patches) and suprapermafrost ground water were collected to compare data from fossil ice wedge and segregated ice with actual climatic conditions.

To investigate the influence of the geomorphological position on the ground ice composition, drilling was performed for 10 bore holes (BH-1 to BH-10) along a transsect between the top of pingo "Mamontovy Bulgunnyakh" through the alas to the Ice Complex (see Figure 5-4). Pingo ice was reached at a depth of 6,5 m.

Sampling was carried out in ice wedges of different ages. Samples were taken according to the structure of ice wedges and the specific character of frost cracking. Samples were taken with an ice screw or a chain saw, and were thawed out on site. Melt water was collected in plastic flasks. 30 ml were taken for stable isotope measurements (^{18}O; ^{2}H) and for tritium analysis. Additionally, ca. 50 ml of water were filtered through 0,45 μm PE-filters and subdivided into two parts. The first part was taken for anion measurement (Cl^-, SO_4^{2-}, NO_2^-, NO_3^- F^-, PO_4^{2-}). The second part was treated with 10% HNO_3 for cation measurement0 (Al, Ba, Ca, Fe, K, Mg, Mn, Na, P, Si, Sr). The measurement of anions will be carried out with an ion-chromatograph type Eppendorf IC 2001, cations will be measured with a Perkin-Elmer ICP-OES Optima 3000 XL. The values of pH and electrical conductivity were measured directly in the camp with WTW instruments.

Tritium (^3H), is a radioactive component of the water molecule, and can be used as an indicator of water movement and of the "modern water contamination" in permafrost (Chizhov and Dereviagin, 1998). Therefore, tritium can be used to check the validity of stable isotope analysis of ground ice. Tritium concentration will be evaluated at the Moscow State University (Department of

Radiochemistry), using a liquid-scintillation spectrometer.

The oxygen and hydrogen stable isotope method has been widely used for hydrological and paleoclimatic studies, i. e. for paleo temperature reconstruction of glacier ice. The experience achieved during these studies will help us to interpretate our results on ground ice. Stable isotope measurements ($\partial^{18}O$ and ∂D) will be carried out at AWI-Potsdam with a Finnigan Delta-S mass spectrometer.

^{10}Be is a cosmogenic radionuclide, which is rapidly removed from the atmosphere by precipitation within one or two years and transferred into ice of the polar regions. The concentration of ^{10}Be is an indicator for the interaction of cosmic rays with the atmosphere, and indicates solar activity and climate variations (Beer et al., 1985). For ^{10}Be analysis two ice wedges were selected and sampled horizontally: BYK-A2 located in the alas (13 samples) and MKh-3 in the Ice Complex (15 samples). With a chain saw cubes of 20 cm in diameter were cut out, thawed, transferred to 1 l PE bottles, treated with suprapure 10% HNO_3 to pH 3-4 and spiked with a 1 ppm ^{9}Be solution. ^{10}Be concentrations will be prepared for measurements at the Institute for Environmental Physics at the University of Heidelberg and measured by accelerator mass spectrometer at the ETH Zurich.

5.4.3 Sampling conception

The sampling conception for ice wedges and segregated ice is illustrated in Figure 5-5.

Black points mark the sampling points in one schematic ice wedge. A principal characteristic for good and correct sampling is the understanding of the cut of the ice wedge. It is most appropriate to sample horizontal and vertical transsects perpendicular to ice wedge growth in order to record the age variations in ice wedges. Every single sample should be taken following the growth structure.

We performed high-resolution sampling. Samples were taken in 10 cm intervals horizontally and in 20 cm intervals vertically. The single annual veinlets can be distinguished because of slight differences in the colour of ice and because of high contents of gas bubbles, which are orientated vertically. They are characterised by widths between 1 to 4 mm, thus our horizontal sampling resolution corresponds to time intervals between 25 to 100 years.

For ice wedge BYK-A2, sampling along one single ice veinlet was carried out to check, whether the working hypothesis (one veinlet represents one year) is correct. All samples along one single veinlet should have the same ∂ values for hydrogen and oxygen. In order to examine exchange processes between ice wedge and segregated ice, careful sampling was performed in the transitional area between ice and sediment.

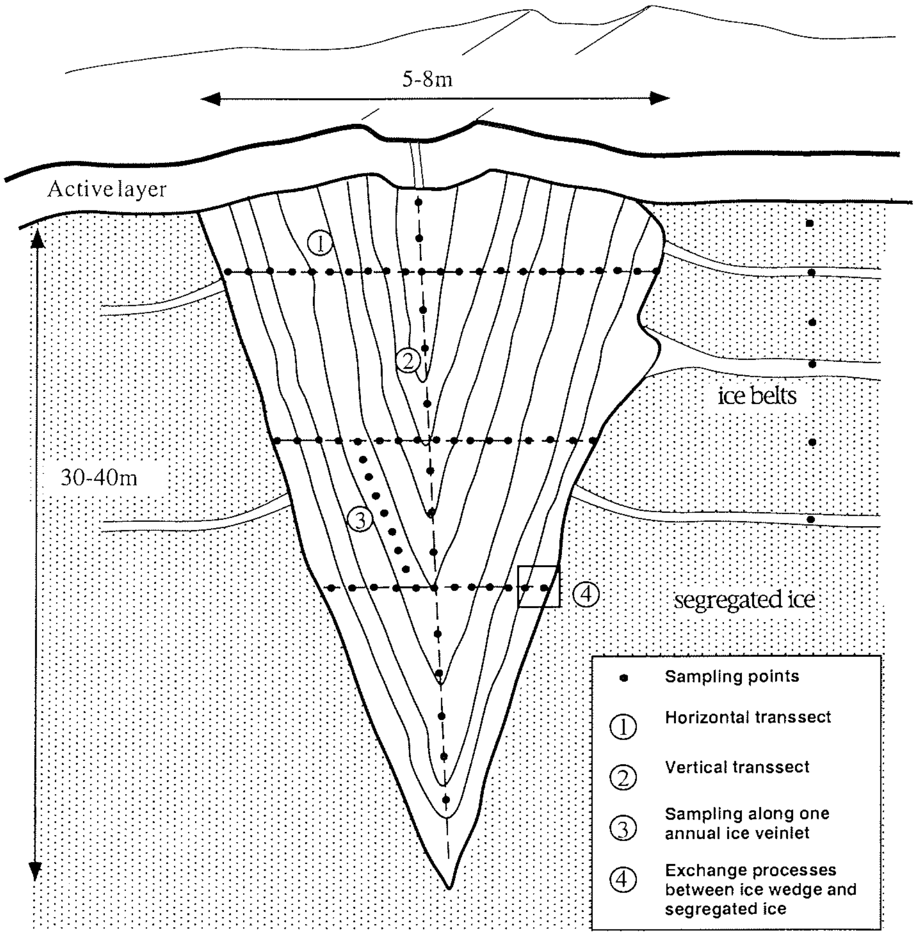

Figure 5-5: Sampling conception for ice wedges and segregated ice.

To get a complete vertical profile, we sampled ice wedges in different height levels of the outcrop (Table 5-3). It is distinguished between mostly huge syngenetic ice wedges with grey, transparent ice and presumably younger ice wedges with white and milky ice. All ice wedges in environments relatively younger to the Ice Complex such as alas or deluvial-proluvial deposits are characterised by white, milky ice wedges. Grey ice wedges are found in the Ice Complex only, containing also some white, milky ice wedges.

Table 5-3: Sampled ice wedges and their respective height above sea level.

ICE WEDGE	Location	Number of samples	Color of Ice	Generations	SAMPLING (Heigt above SL)
MKh-1.1	Proluvial sediments	4	white, milky	1, (younger)	15 - 17 m
MKh-1.2	Ice complex	49	grey, transparent	1, (older)	2,5 - 3,0 m
MKh-1.3	Proluvial sediments	10	white, milky	1, (younger)	16,1 - 17,1 m
MKh-1.6	Proluvial sediments	5	white, milky	1, (younger)	19 - 20 m
MKh-3	Ice complex	134	grey, transparent	1, (older)	8,6 - 12,9 m
MKh-4.6	Ice complex	51	grey, transparent and white, milky	2, (older & younger)	36,0 - 37,2 m
MKh-4.13	Ice complex and proluvial sediments	55	grey, transparent and white, milky	2, (older & younger)	21,5 - 23,9 m
MKh-5	Ice complex	74	grey, transparent	1, (older)	19 - 20 m
MKh-KR and -KK	Ice complex	22	grey, transparent and white, milky	3, (1 older & 2 younger)	9,2 - 16,8 m
MKh-K8a	Ice complex	3	white, milky	1, (younger)	17 - 18 m
BYK-A1	Alas and ice complex	13	black and white, milky	2, (older & younger)	1 m
BYK-A2	Alas	148	white, milky	1, (younger)	2,0 - 5,6 m
BYK-H	Alas	15	white, milky	1, (younger)	5,1 m
other ice wedges		7			
total		**590**			

In total, 13 ice wedges were sampled (see Table 5-3 and Figure 5-9). Most intensive sampling was carried out for ice wedges MKh-3 in the Ice Complex and for BYK-A2 in the alas (2 horizontal and 1 vertical transsects, respectively). Both were cut by coastal erosion perpendicular to their respective growth structures and were relatively easy to reach and to sample in different heights.

Some ice wedges were sampled because they contain two or more generations of ice wedges (Table 5-3). BYK-A1 shows the contact between Ice Complex (with C_{org} rich, black ice) and alas, Mkh-4.13 the contact between Ice Complex and deluvial-proluvial sediments. Some young, narrow ice wedges were chosen to compare recent climatic conditions to subrecent or recent ice wedge growth. Additionally, all modern "heads" of ice wedges were sampled. Segregated ice was sampled vertically including ice belts and active layer ice.

In addition to geochemical investigations of ground ice, the ice structure was studied using polarising lenses. This is an important method to get information about the ice wedge formation and is based on specific characteristics of ice crystal size, shape and orientation, which represent the conditions of crystallisation (Solomatin, 1974). For this purpose thin slides of ice were cut out of ice wedges (Mkh-1.2, Mkh-3, Mkh-5, Mkh-4.6), melted to a thickness of about 2 mm and analysed in the field under polarising lenses.

5.4.4 First results

The results of pH and electrical conductivity measurements (Table A5-1, Appendix) show:

The ice wedge conductivity is lower generally than 500 µS/cm, but some higher values were observed for the edges of ice wedges. pH varies between 5,5 and 9 for all ice wedges. Segregated ice is characterised by higher conductivities up to 5500 µS/cm and a smaller pH range between 5,5 and 8,2. The following two figures show exemplarily the variations of pH and electrical conductivity for ice wedge MKh-3.

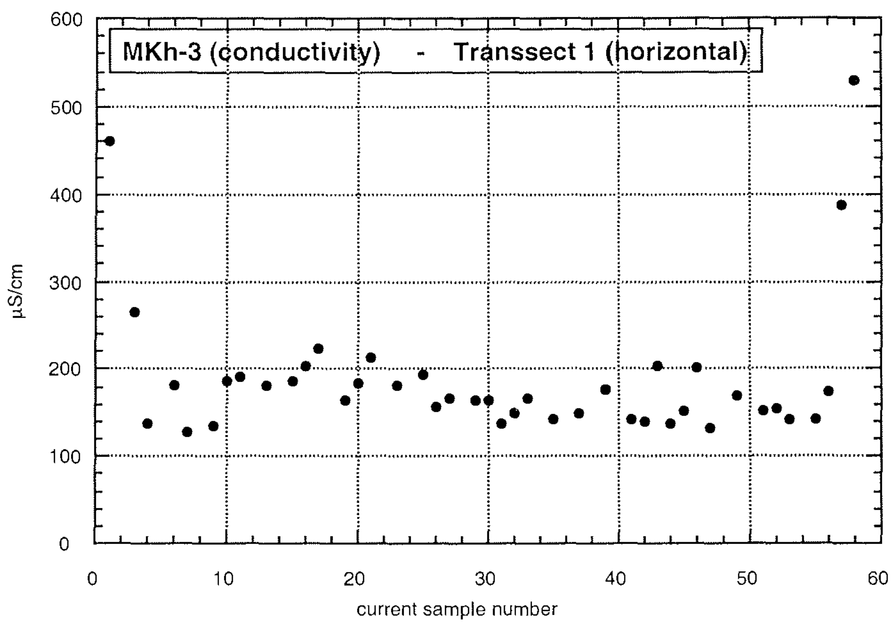

Figure 5-6: Electrical conductivity for ice wedge MKh-3.

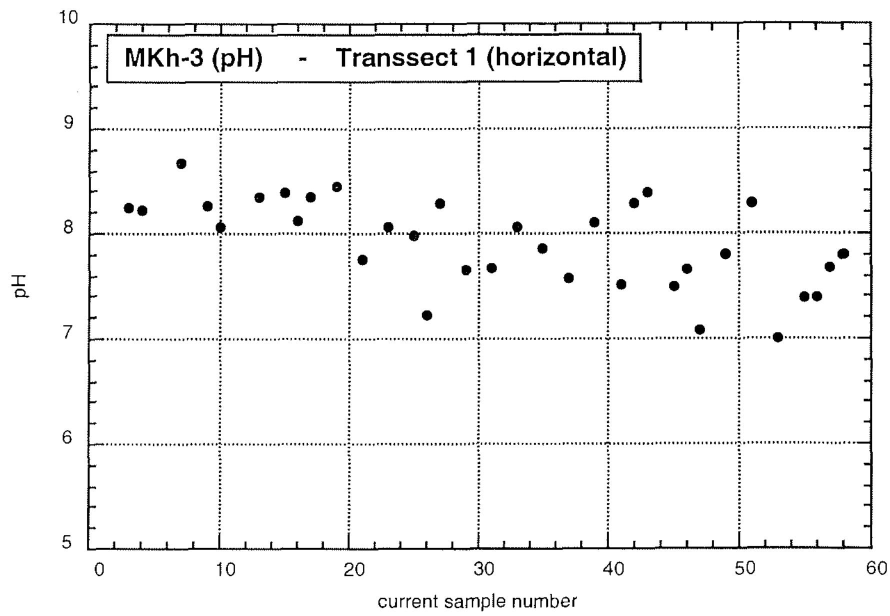

Figure 5-7: pH for ice wedge MKh-3.

The electrical conductivity and pH for ice wedge MKh-3 are represented for one horizontal sampling transsect. Electrical conductivity varies between 127 and 528 μS/cm, pH between 7,01 and 8,87. The highest values for the electrical conductivity are observed for the edges of ice wedge MKh-3. The middle part shows constant values between 150 and 250 μS/cm. The high conductivity in the interface of ice and sediment point to exchange processes between ice wedge and sediment. In the future more attention should be paid to this process. The small differences for pH can probably be attributed to varying content of organic matter.

Preliminary results of anion and cation analysis show that the most important cations in ice wedges are Ca, Mg and Na, the most important anions are Cl^- and SO_4^{2-}. More attention will be paid to hydrochemical analysis in the future.

The studies of ice structure using polarising lenses showed differences of crystal parameters from the upper part (Mkh-4.6) to the middle (Mkh-5) and the lower part of the outcrop. In the upper part of the section ice crystals are bigger and have more elongated form.

First preliminary results of tritium analyses show that the background tritium content varies from 16±8 to 46±11 TU (tritium units). Results for precipitation and snow patches point to a modern (this year) deviation of the tritium concentration in the region. The data on tritium concentration in modern snow vary from 123±14 to 207±16 TU. Tritium concentration in the samples of segregated ice, taken from the base of active layer at bore hole locations BH-1 to BH-10 (see Figure 5-4), vary from 105±12 to 219±18 TU. These results point out to the modern (several years) deviation of the tritium concentration in the upper part of the permafrost. "Young" ice wedges show tritium concentrations varying from 98±13 to 169±17 TU. Tritium content in the heads and upper part of ice wedges (sections Mkh-1.6 and Mkh-1-3) indicates a modern growth of these ice wedges. The tritium analyses of the pingo ice core (BH-3) point to the presence of "modern water". The tritium concentration in the upper part of the ice core is more than 130 TU.

Generally, first results of tritium analysis point to the intensive modern water exchange in the system: precipitation - active layer - upper part of permafrost and to the activity of modern cryogenic processes in this region.

5.5 Cryolithological studies

(L. Schirrmeister, C. Siegert, V. Tumskoy and V. Kunitzky)

5.5.1 Methods

As known perennially frozen sediments include information on both the sediment genesis and on the freezing conditions. Therefore, during field work sediment characteristics as well as the cryogenic structure have been investigated (Figure 5-8).

We tried to describe colour, grain size, presence of fossils and sedimentary structures (e.g. cryoturbations, small sandy layers or ripples) for all sediments. The description of the cryostructure includes the morphology and size of segregated ice and the ice content (W_g) determination by help of a simple gravimetric field method. For the latter the following operations have been carried out:

1-sampling of frozen sediments in lockable aluminium boxes;

2-weighing of wet sediment (M_{frozen});

3-drying of sediments on a little stove;

4-weighing of dried samples (M_{dried});

5-calculation of the ice content: $W_g = \frac{(M_{frozen} - M_{dried})/ M_{dried}}{\times 100\ \%}$

Mostly the sediments were frozen, and samples were taken with small hatchets and a hammer. In the camp the samples were divided into two small parts for palynological and micropaleontological analyses and a larger part for sedimentological studies. Firstly, after thawing water was sucked off for stable isotope and hydrochemical analyses (see Chapter 5.4). The wet sediments were air-dried. After the final drying in the laboratory, the weight of most sample was 300 to 500 g.

Cryolithological Studies

sediments		segregated ice
colour grain size organic remains sedimentary structures	description	ice content size, morphology and spatial distrubution of ice
carbonat content (x = less; xx = more; - = without	field analyses	Ice content (gravimetric on dry-weight-basis)
frozen sediments; thawing; splitting for palynology; diatomen analyses; sediment analyses; drying; dry-weight 300-500 g	sampling	sucking off of water from thawed samples for isotopic and hydrochemical analyses

Figure 5-8 :Schematic overview of cryolithological studies.

Field studies at individual sites within the outcrop complex "Mamontovy Khayata" were determined by its large extent and restricted by the accessibility of local profiles. The permanent thermal erosion led to changing working conditions from day to day. Therefore, some parts of the outcrop have been studied more in detail, whereas other sites have been only exemplarily sampled. The upper parts of the coastal cliffs were well exposed, but they were hardly accessible because of the steep and slippery surface of the dominant ice wedges. The middle and lower parts of the outcrop were extensively buried by muddy slope sediments. Only some small profiles of 1 to 2 m high at the bases of thermokarst mounds (baydzharakhs), in temporary thermal erosion channels and below the present abrasion edges near the shore line could be studied.

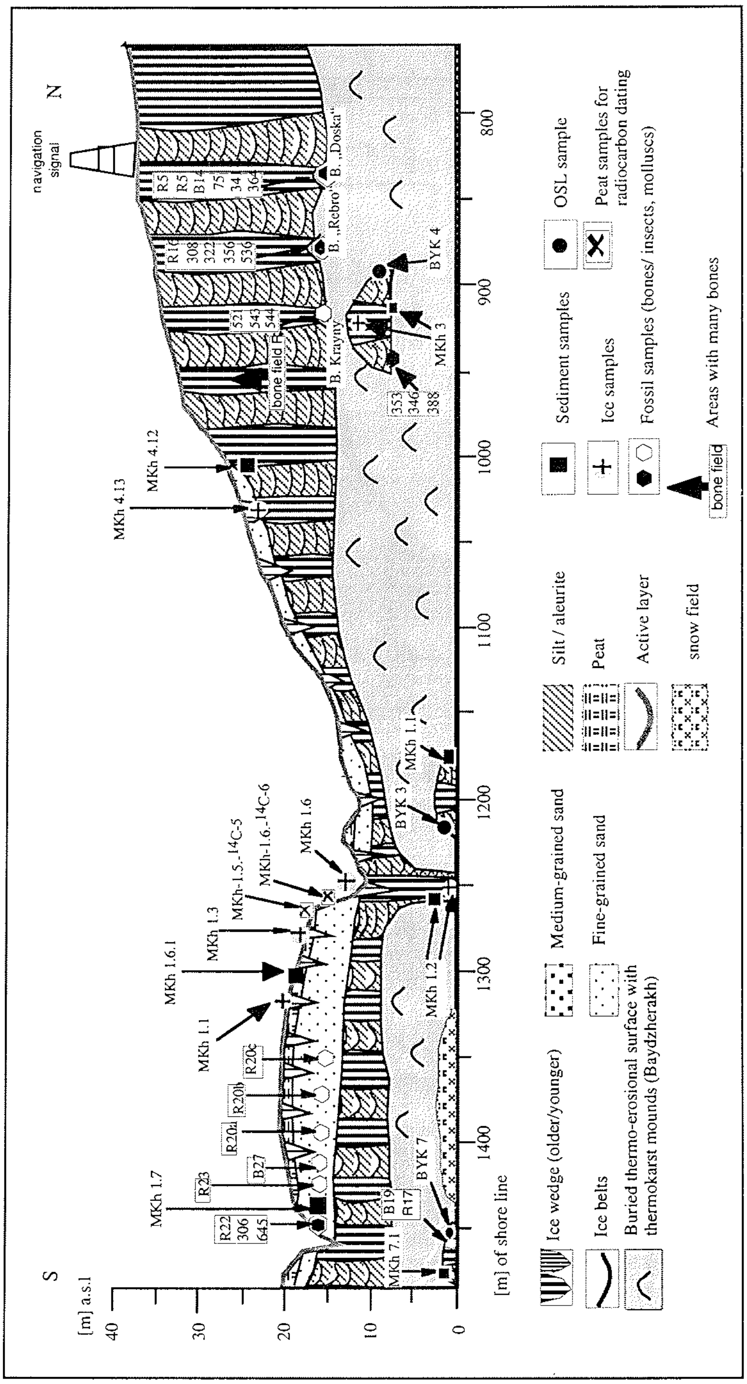

Figure 5-9 a: Outcrop "Mamontovy Khayata" - Southern part.

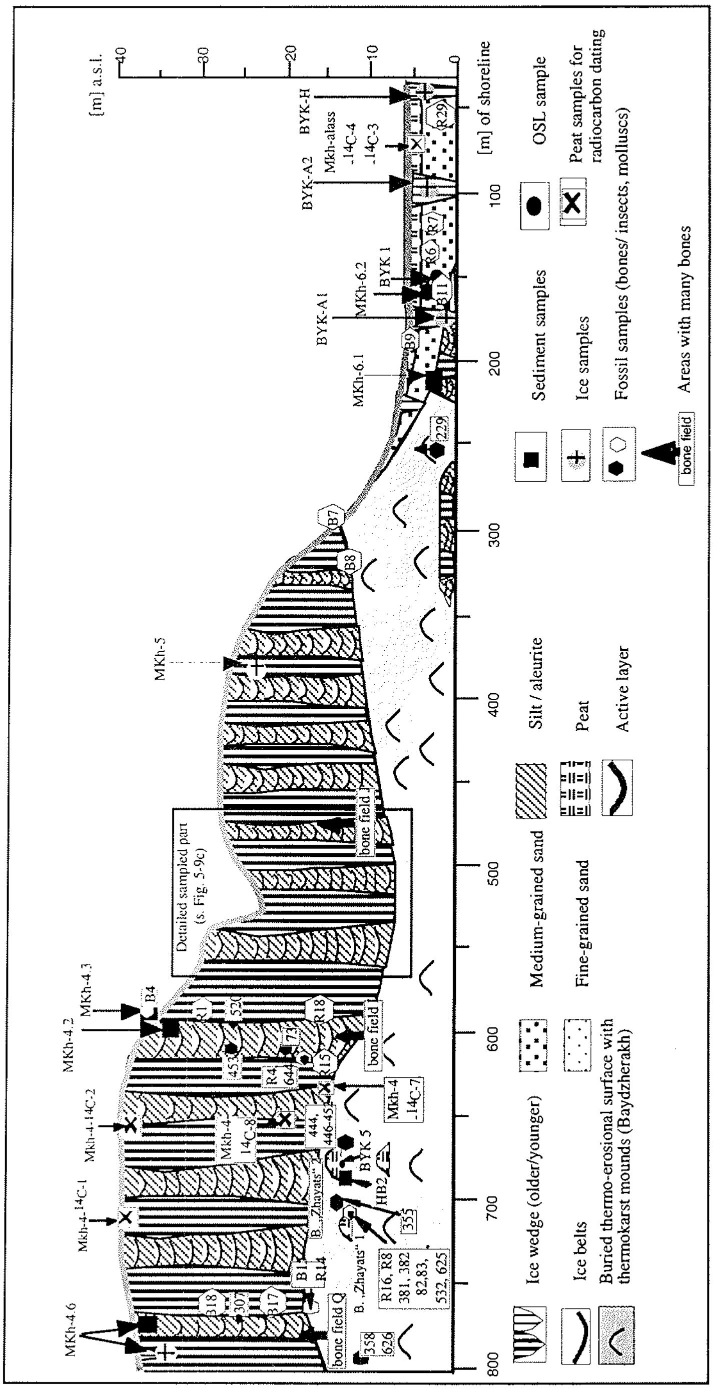

Figure 5-9 b: Outcrop "Mamontovy Khayata" - Northern part.

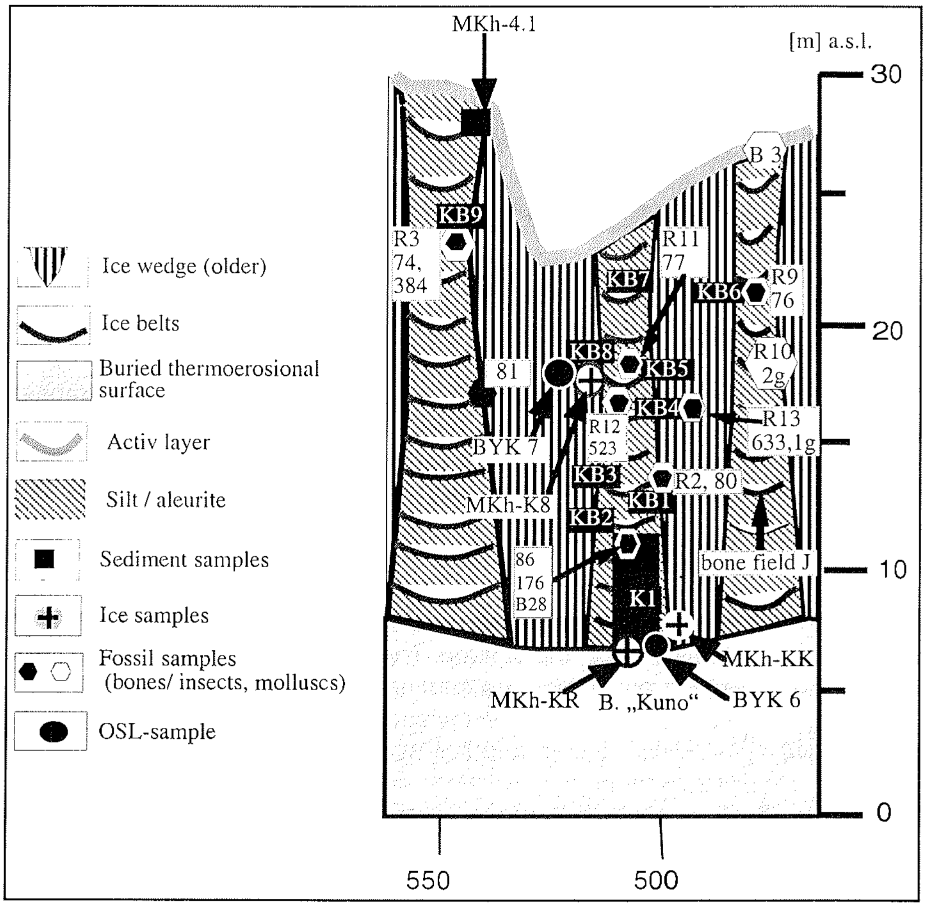

Figure 5-9 c: Detailed sampled part of "Mamontovy Khayata".

Cryolithological studies have been carried out in the following step (s. Figure 5-9 a-c and Figure 5-1):

1. Division of outcrop sections of Ice Complex of Mamontovy Khayata;
2 Levelling of vertical profile lines, shore and coastal line and typical outcrop areas;
3. Detailed, in parts overlapped geocryological survey of soil sequences at thermokarst mounds (baydzharakhs) from 10 to 25 m a.s.l. (Mkh K1 -KB1-KB2-KB3-KB4-KB5-KB6-KB7-KB8-KB9-MKh4.1-4.2-4.3);
4. Exemplary study of poorly exposed sections near the shore line (Mkh 1.1 - 1.2. - 7.1);
5. Study of sediment blocks and peat horizon in the middle part of the outcrop complex of Mamontovy Khayata (Mkh 3 - HB2 - BR);

6. Investigations of a peat bed and of sandy sediments (presumably of fluvial-deluvial origin) overlying the Ice Complex at the top of the steep cliff (Mkh 4.6 - 4.12 - 1.6 - 1.7);
7. Study of the alas sequences adjacent to the north (Mkh 6.1 - 6.2 - 6.3 - MB 1.1);
8. Additional study of Ice Complex outcrops in the northern part of the Bykovsky Peninsula (M 1.1 -1.2 - 1.3; B);

5.5.2 First results

Results obtained in field work show that the main studied area is characterised by three facies of permafrost deposits - Ice Complex, deluvial-proluvial deposits and alas deposits. The Ice Complex sediments of the section Mamontovy Khayata (Mkh) (Figure 5-9 a-c) are represented by grey, ice-rich, carbonated silts with relatively rare plant and peat inclusions alternating with brownish cryoturbated peaty soil horizons with low ice and carbonate contents and a lot of plant material. This alternation is interpreted as a sequence of Tundra paleosoils. The frequency of soil horizons and the content of plant and peat inclusions increase to the top of the outcrop. The entire outcrop was divided into five different working areas, which are summarised to a normal profile (Figure 5-10). The first lower level occurs from the shore to about 12-15 m a.s.l.. These deposits are poor in plant fossils and soil horizons. A peat bed of about 1 m thickness, exposed in some neighbouring thermokarst mounds, was found at the altitude of 15 m a.s.l.. The upper level of the Ice Complex starts from around 12-15 m a.s.l. and is characterised by numerous soil horizons (mostly cryoturbated peaty soils) and a high content of plant fossils, such as wood and grass roots. This sediment sequence is covered either by a peat horizon of about one meter thickness or by sandy sediments accumulated in a wide run-off valley. The latter is also overlain by a peat horizon. At the northern end of the outcrop complex Mamontovy Khayata (Mkh) alas deposits are inserted into the Ice Complex. In the lower part this alas sequence consists of fine to medium grained sands with ripple texture containing numerous large wood remains, whereas the upper part is formed by a peat horizon. Below the alas sands some eroded large ice wedges of the Ice Complex were observed.

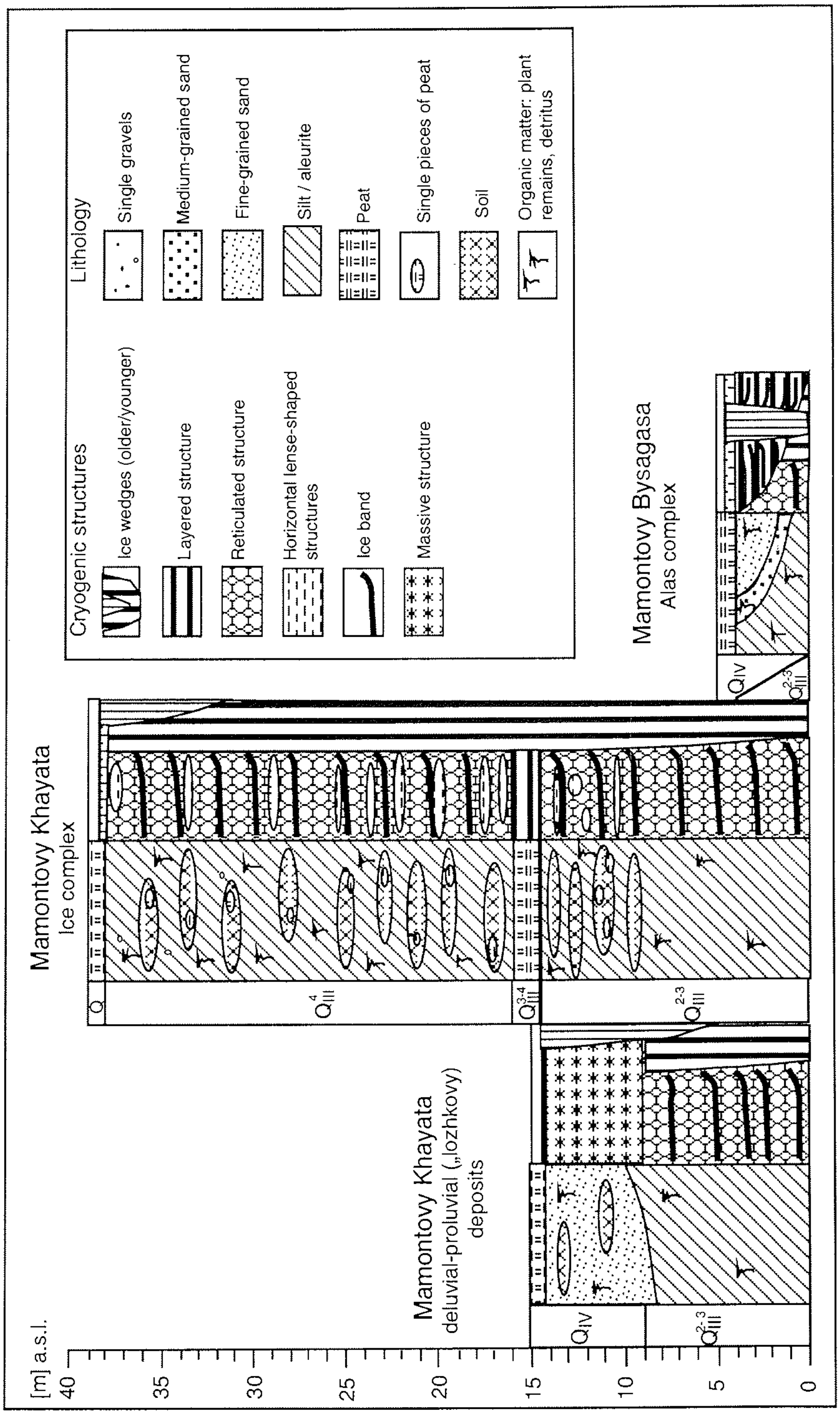

Figure 5-10: General section of typical permafrost deposits on the Bykovsky Peninsula.

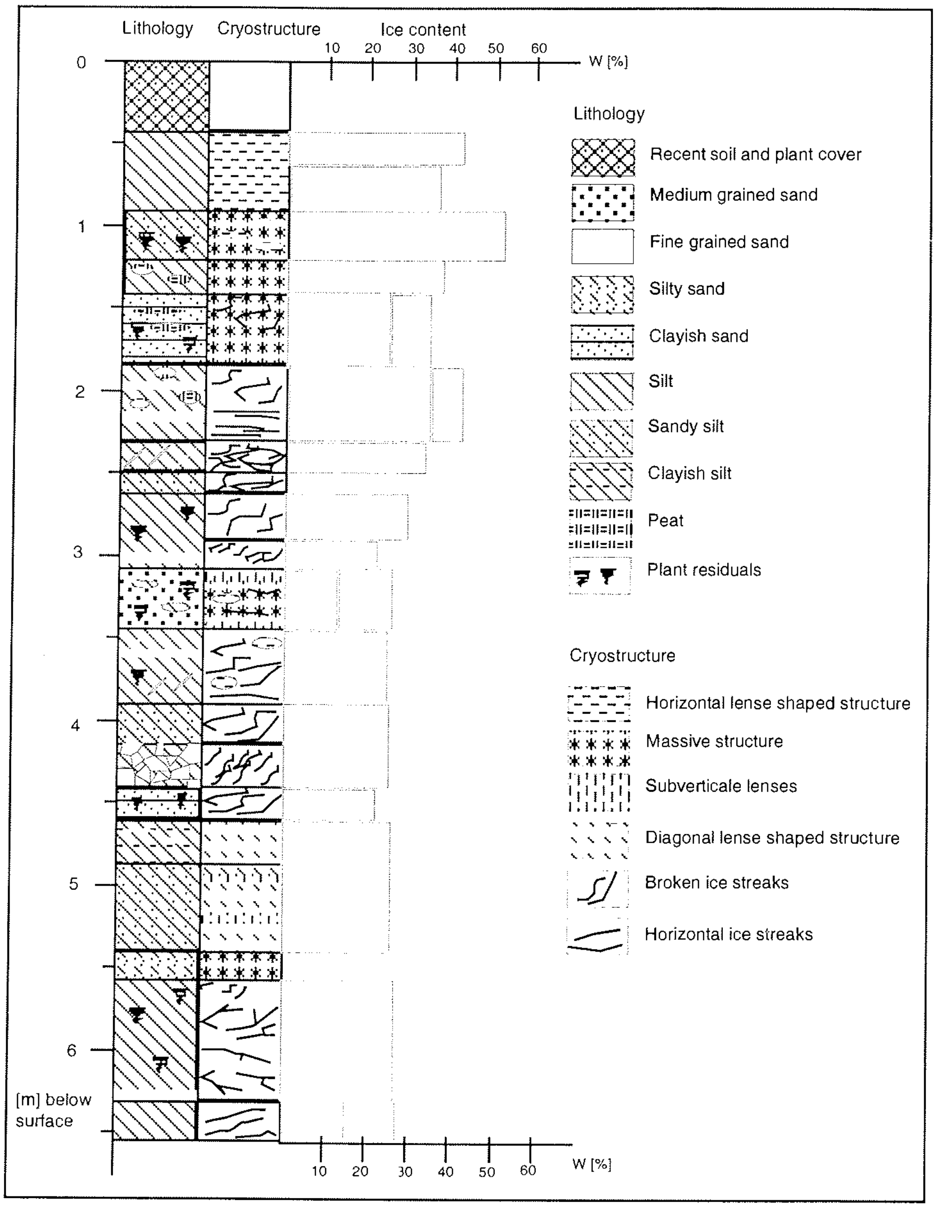

Figure 5-11: Lithology, cryostructure and ice content (gravimetric) of alas sediments at the top of the Pingo "Mamontovy Bulgunyakh" (28 m a.s.l.); Drilling profile BH 2 ; for Position see Figure 5-4.

Another coastal outcrop was studied to the north of our camp (Figure 5-1), where a terrace of about 5 m above the alas bottom was exposed. This section consists of redeposited silts and sands enriched with plant fossils. A layer of wood trunk fragments occurs. At the shore level the redeposited horizon seems to cover silty sediments similar to those of the Ice Complex.

The structure of the pingo "Mamontovy Bulgunyakh" (500 m to the northwest of the camp, Figure 5-4) was studied by core drilling. The results show that the pingo consists of dense sandy-silts with a low ice content. Such permafrost deposits develop by thawing of ice-rich sediments in taliks and subsequent refreezing after the drying of the thermokarst lake. Cross-bedded lacustrine sands and layers with plant remains occur. The pingo ice was reached at 6,5 m below the surface (Figure 5-11).

Furthermore, a reconnaissance study of two coastal outcrops in the northern part of the Bykovsky Peninsula (Mamont Mys, Bykovsky-North, Figure 5-1) was taken during one-day-expeditions. Both outcrops have a similar appearance to the Ice Complex of Mamontovy Khayata, and contain also sandy horizons on their top. In the Bykovsky-North outcrop these sands have a thickness of 5 m and overlie silty sediments of the Ice Complex with a clear discordance.

The cryostructure of perennially frozen ground at the most study sites is dominated by ice-layering (banding). Some ice bands have thickness of 1 to 10 cm. Such thick ice bands are formed by repeated thawing and freezing during a stable situation of the active layer/permafrost boundary for a prolonged time. Therefore, they indicate syngenetic freezing of sediments under stable surface conditions. The sediment interlayers are characterised by reticulated lens-shaped (lens-like) cryostructures - from coarse to micro reticulated lens-shaped. Buried soil horizons have a lower ice content than the above described deposits of the Ice Complex and show fine lens-shaped cryostructures, often with additional subvertical ice streaks. These are typical features for the upper horizons of a former active layer. The ice content of soil horizons is around 60 to 100 % relatively to the dry weight of sediment, and 100 to 200 % in silty deposits between the soil horizons. The sandy alas deposits have ice contents of 40 to 60 % (see Table A5-2, appendix)

5.6 Geochronometric age determination

(L. Schirrmeister; M. Krbetschek, A. Sher and V. Kunitzky)

The existing ^{14}C and TL (thermoluminescence) ages from the study region do not allow to establish a detailed geochronology. These data are mostly from single localities and positions within sediment sequences and do not satisfactorily represent the geochronometry of the whole sequences About 30 radiocarbon dates are published for the Quaternary sediments of the Bykovsky Peninsula (Ivanov and Katasonova, 1979; Tomirdiaro et al., 1984; Valis´chuk, 1988; Kunitsky, 1989; Fartichev, 1993; Slagoda, 1993; Nagoaka, 1994; Nagoaka et al., 1995). Almost 20 samples were dated from the Mamontovy Khayata area (including adjacent alasses). Only five samples come from the upper part of the Mamontovy Ice Complex, and they range from to 20,835 ± 150 y BP (IM-749) to 28,300 ±370 y BP (NUTA-2839). According to Fukuda (1994), the sample from the uppermost part of the cliff (ca 37 m a.s.l.) dated 11,090 ± 270 y BP (NUTA-2231) comes not from the Ice Complex itself, but from the overlying peat. The date 28,300 ±370 y BP is in controversy with the younger dates obtained from the lower altitudes of the cliff; however, the exact position of the sample NUTA-2839 is dubious, since it is indicated in different ways in subsequent reports of the Japanese scientists. The remaining three dates from the upper Ice Complex are all around 21-22 ka; thus, the Sartanian age is not represented for the most of its accepted duration.

The largest number of samples was dated from a relatively thick peat in the middle part of the cliff. Although different Russian authors give various estimates of its altitude - from 15 (Kunitsky, 1989) to 20 m a.s.l. (Slagoda, 1993), it can be assumed that they sampled the same horizon. It is more difficult to interpret the exact position of the samples taken by the Japanese colleagues due to uncertainties in their reports. Most Russian dates from the peat concentrate around 28 to 33 ka. One date, however, is as young as 22,200 ± 930 y BP (IM-748); it is also possible that some infinitely dated samples (> 45,000 y BP) come from the same horizon (Slagoda, 1993). The lower part of the Mamontovy Khayata cliff (below 15 m a.s.l.) has actually never been sampled, but it is generally assumed that it is older than 45,000 y BP. Peats in the alass sections are dated about 9,000 years and peats on the top of the Ice Complex reange from the mentioned 11,000 y BP to as young as 3,000 years.

Some radiocarbon dates from the Lena Delta area were reported by Kuptov and Lisitsin (1996). A few Holocene dates between around 2000-4000 years have been obtained from the Samoylov Island. Strongly mineralized wood samples from various levels of exposure at the Trofimovsky branch bank have shown the radicarbon ages between 11,000 and 17,000 years BP; it seems very likely that all these samples were essentially contaminated by younger (modern) carbon. According to Kunitsky (1989) a peat horizon interbedded in the Ice Complex deposits on the right bank of the Oleneksky branch is older than 36.000 years.

The above summary shows that radiocarbon dating of the Ice Complex faces many problems. That is especially clearly demonstrated by controversies in the dating results obtained by the same field team during one field season, such as essential age inversions through the section, which may indicate possible methodical problems.

There are also a few sediment datings from the Lena Delta area based on the thermoluminescence technique (TL) (Table 5-4). Therefore, a more exact geochronometric dating of Pleistocene and Holocene sediments in the Lena Delta region is necessary for their stratigraphical classification and also for the reconstruction of paleoprocesses in the Laptev Shelf and the Lena Delta.

Table 5-4: TL age determination of Ice Complex sediments near the sea level of the outcrop "Mamontovy Khayata" and of the northern part of the Muostakh Island (sampled and compiled by V. Kunitzky, Yakutsk).

Material, sampling year	Locality	[m] a.s.l.	Age [a B.P.]	Lab.-number
Silt/aleurit 1996	Bykovsky Peninsula, "Mamontovy Khayata"	5	54.000±13.000	RTL-761
Silt/aleurit 1996	Muostakh Island, Northern part	2	77.000±19.000	RTL-760
Silt/aleurit 1996	Muostakh Island, Northern part	5	89.000±22.000	RTL-759

This chapter represents all field activities of the entire expedition "Lena-98" concerning age determination by different physical methods. Radiocarbon and OSL (Optically Stimulated Luminescence) dating will be mainly applied. In addition, U/Th-age determination is to be tested on some peat samples from different positions in the Ice Complex. An overview and the used methods are given in Table 5-5.

Samples for radiocarbon dating were taken from deposits of the most important facies using outcrops at the bank of the Laptev Sea and the Lena river as well as by the help of core drilling. This concerns the intrapolygonal sediment blocks of the Ice Complex, sandy deposits of alases, sands of periglacial valleys on the top of the Ice Complex, as well as different peat horizons. Depending on the accessibility of deposits in the outcrops the sampling density varies. There are samples taken in detail in profiles with numerous soil horizons (Figure 5-12) and in some peat beds. In other outcrop areas it was possible to take samples only exemplarily. We tried to date the base and the top of each local profile, typical horizons, which are interbedded in the ice complex, and if possible the deposits situated below the Ice Complex. This sampling allows to determine the age of the complete investigated sequence (Figure 5-13 a/b).

In the recent years, bone collagen is more and more recognized as a reliable dating material, especially in permafrost areas. According to Sulerzhitsky (1982, 1998) it is often less subjected to carbon contamination than the plant remains. We submitted 40 bone samples from the Bykovsky Peninsula localities to a laboratory where the technique of conventional bone dating is the most developed, and hope to obtain unparalleled series of dated bones from one locality (Mamontovy Khayata) (Table A5-3, appendix). Five bones sent to the laboratory were found strictly in situ in the Ice Complex at various altitudes between 13 and 26 m a.s.l. There are several more bones found in situ, but for their small size they cannot be dated by conventional method, so we may consider their AMS dating in future if required (judging from the results of the first series of dating). About 20 bones found in the mud flows within the cliff, and characterise more or less broad vertical range of the section. Some of them may hopefully come from the upper, the least accessible part of the section. The other bones submitted for dating are thought to characterise a broader time range and to find out the time of existence of certain mammalian species.

Table 5-5: Overview of methods, material and laboratories used for geochronometry studies.

Dating-method	Time range	Material	Laboratory
Radiocarbon AMS	$10\text{-}5 \cdot 10^4$ a	small plant remains in sediments and ice wedges	Leibniz-Laboratory for age determination and isotopic studies, Kiel
Radiocarbon, conventional	$10\text{-}5 \cdot 10^4$ a	big peat and wood samples	Permafrost Institute Yakutsk; Alfred Wegener Institute, Research Unit Potsdam
		bones	Geological Institute, Russian Academy of Sciences; Moscow
IR-OSL	10^3 - $2 \cdot 10^5$ a	fluvial and lacustrine sandy to silty deposits	Saxon Academy of Sciences, Quaternary Geochronology Section; Freiberg
U/Th	10^3 - $5 \cdot 10^5$ a	peat inclusions	Lower Saxon Survey of Soil Research, Hannover

The large part of investigated deposits contain plant fossils (grasses, roots, fine twigs, seeds). They will be dated by the AMS-Method (Accelerator Mass Spectrometry) of radiocarbon dating. The conventional radiocarbon method will be applied for the age determination of authochton peat horizons and bones. Luminescence dating is in use for sandy and silty sediments without organic material as well as for sediments older than 45.000 years. Therefore, the luminescence dating is useful for examining complications, which can occur if allochtone wood or other plant remains are dated by the radiocarbon method.

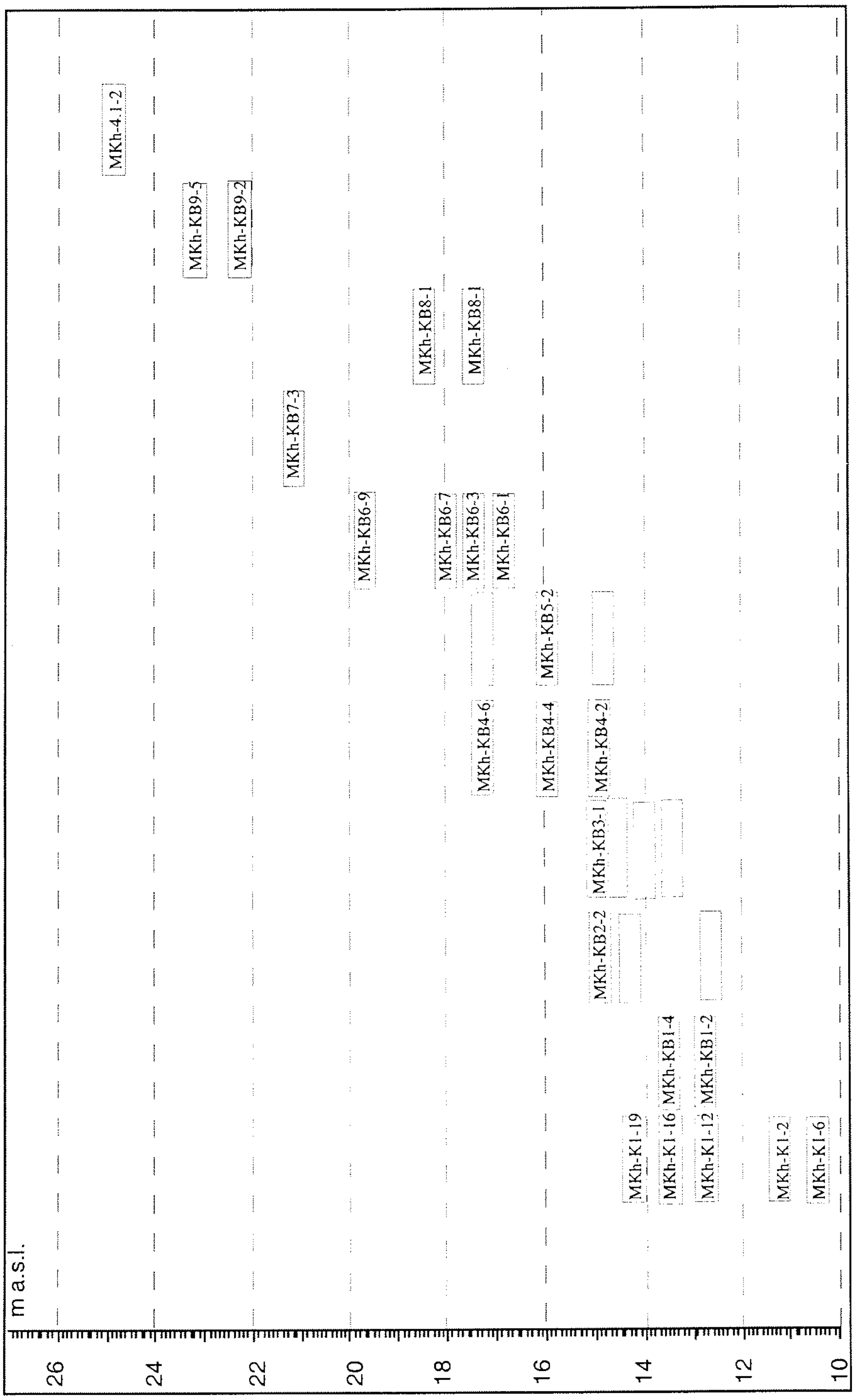

Figure 5-12: Positions of soil horizons in the detailed sampled upper region of the outcrop "Mamontovy Khayata" (see Figure 5-9 c).

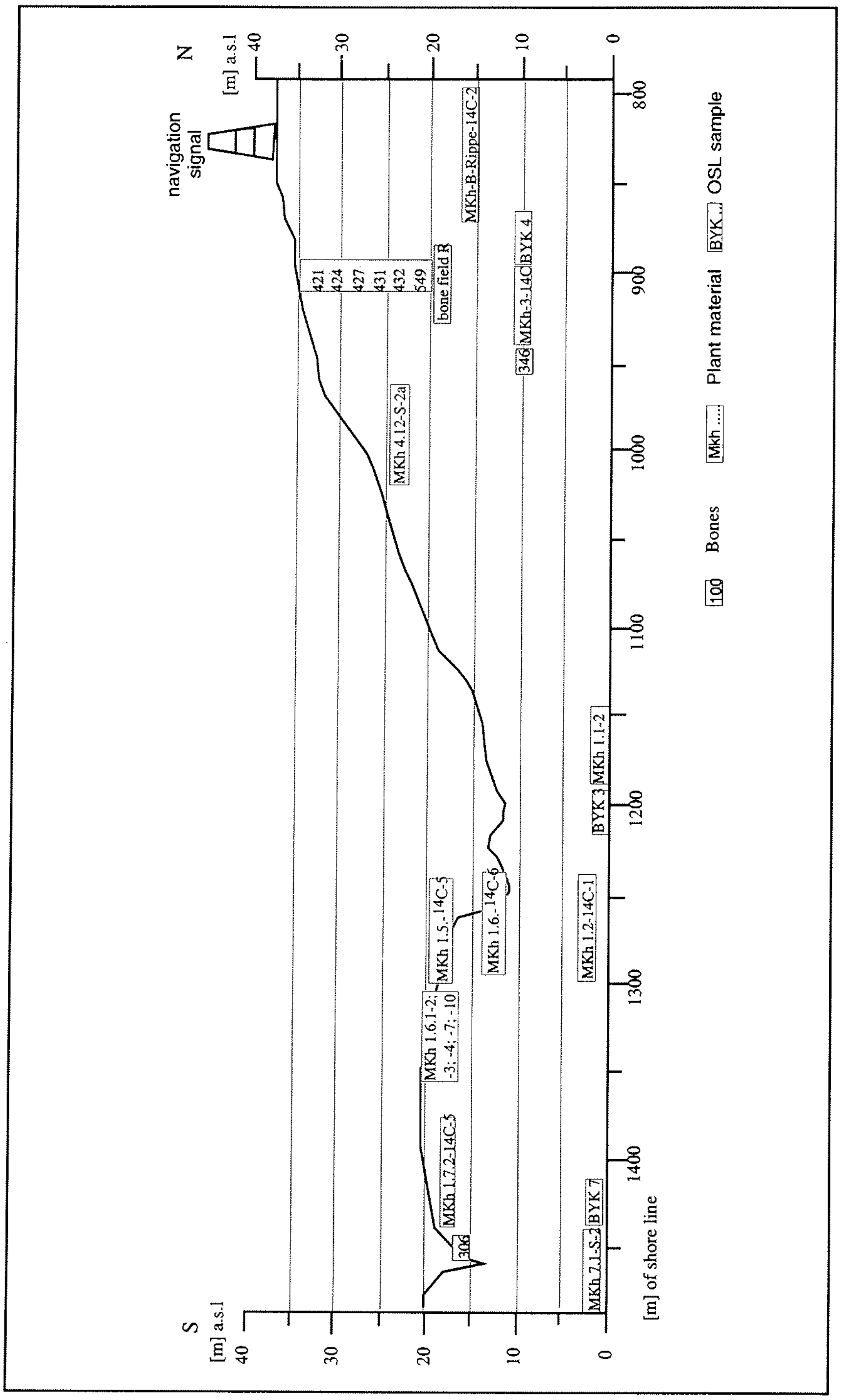

Figure 5-13 a: Position of samples for age determination, Southern part of the outcrop "Mamontovy Khayata".

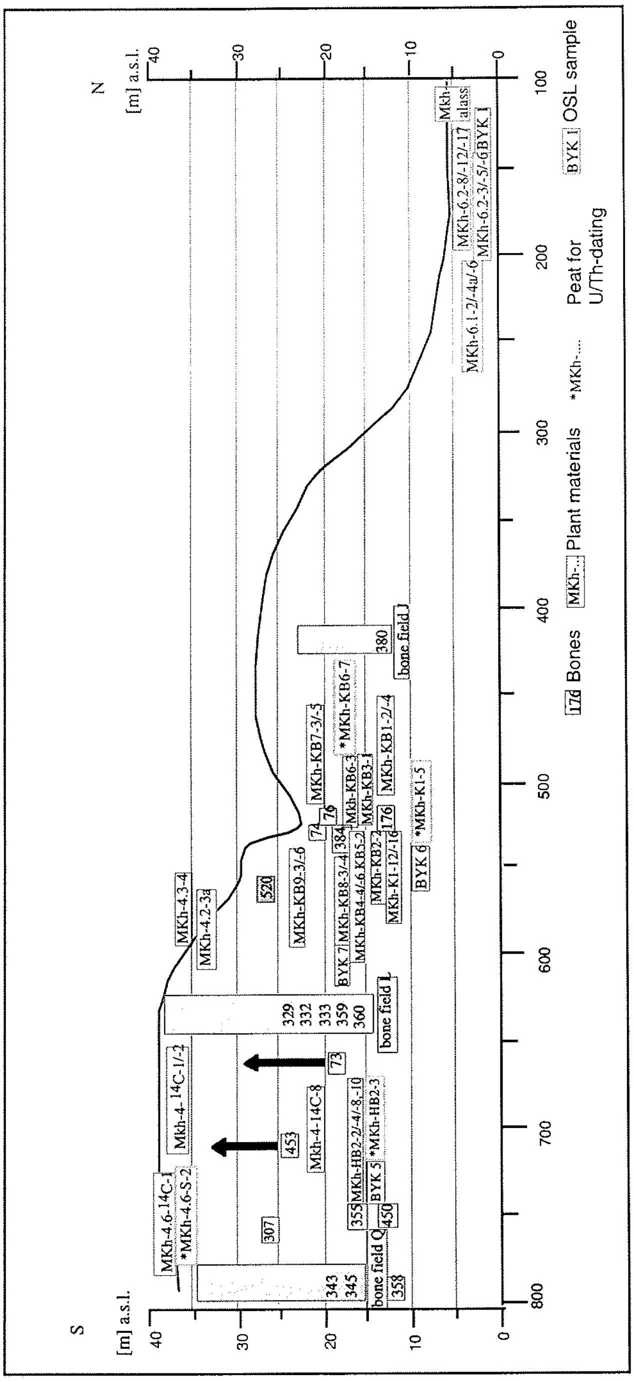

Figure 5-13 b: Position of samples for age determination, Northern part of the outcrop "Mamontovy Khayata".

The luminescence dating techniques on sediments are based on the resetting of the TL or OSL signal due to light exposure of mineral grains (mainly quartz or alkali-feldspar is used) during erosion, transport and deposition. In case of TL most of the signal needs 15 to 20 h direct sunlight to bleach to a low residual level, which can be reconstructed in the laboratory. This is not fulfilled for any of the sediments, especially not for waterlaid types, were water and suspended sediments reduce the "zeroing-effect" of the natural sunlight exposure, which, in addition, can be shortened by completely lacking in polar regions. Age overestimation is caused by insufficient TL bleaching and it has to be mentioned that the existing TL ages may be affected by such a source of uncertainty.

The OSL method just deals with the very light sensitive part of the luminescence signal. Compared to the relatively slow optical resetting of TL, the OSL signal is reduced to zero in a couple of minutes, also without direct sunlight. This guarantees a complete signal-reset also for most waterlaid sediments. However, it is known, that insufficient light-bleaching may occur, at least for a number of grains, especially for sediments with short transport and/or under conditions of reduced exposure (e.g. glaciofluvials, high suspended river sediments).

Feldspar minerals have special characteristics in OSL - they can be stimulated by near IR light. The alkalifeldspar IR-OSL method will be applied to date sediment layers of different origin where samples have been taken during field work. There are published just a few dating studies on sediments from polar regions (e.g. Krause et al.,1997). To get more knowledge about the IR-OSL level at the time of deposition, which is important in respect to the problems of zeroing mentioned above, surface (1-5 cm) samples have been taken from different points of recent sedimentation. Such places were at the bottom of Nikolay Lake (Arga) at water depths of 0.5 to 10 m, at the beach in front of Mamontovy Khayata and mud circles in a nearby alas (both at the Bykovsky Peninsula) as well as at Somoylov island, where recently accumulated river sediments had been sampled. The investigation of these samples will allow the evaluation of possible uncertainties due to insufficient bleaching of the IR-OSL signal during transport and deposition. Clastic deposits have been sampled for geochronometric dating by IR-OSL at the Mamontovy Khayata (BYK 1 to 7) and Bykovsky-North (BYK 7-10) on the Bykovsky Peninsula; at the Arga Island (LD98-D01, sediment sequence Nikolay Lake, S-beach, ARG 1 to 5) and at two fluvial sediment sequences in the Olenjok-Channel (LD98-D6: OLE 1 to 6 ; LD98-D7: OLE 7 to 10). Especially at the Mamontovy Khayata and from the profiles of the Olenyoksky branch samples were taken partially parallel to that for radiocarbon and U/Th-dating.

5.7 Paleontological research on the Bykovsky Peninsula

(S. Kuzmina, T. Kuznetsova and A. Sher)

5.7.1 Methods

Perennially frozen Pleistocene sediments in Arctic Siberia provide perfect preservation for the remains of various organisms. They range from complete frozen carcasses of mammals to the smallest parts of insect chitin exoskeleton, plant seeds and *in situ* grass roots. These fossils provide unparalleled direct information about the past life and environmental conditions (vegetation, soil cover, moisture supply) and important proxy evidence for the reconstruction of the past climate.

Paleontological significance of various groups of animals and plants is different. Large and small mammals had the highest rates of evolution during the Late Cenozoic, so their fossils are essential to define the relative age of the sediments. They also have general paleoecological implications. Besides their paleobiological value, fossil mammal bone collagen presents one of the best organic materials for reliable radiocarbon dating. The most recent pioneering studies of the isotopic composition of bones promise a new source of paleobiological information.

Other groups of organisms, such as plants and insects, do not show significant evolution during the Pleistocene, but they are quite often much more sensible environmental indicators. That is especially true for insects, which may provide a very detailed signal of the past vegetation and the generalised biotopic pattern. The study of plant macrofossils offers direct indications to the plant species that inhabited the past landscape, and is especially valuable for the primary localities, such as autochthonous peats. Fossil freshwater molluscs, diatoms, and ostracodes characterise the conditions of local water basins. Oribatid mites, a group at the initial stage of study, can provide important clues for the understanding of soil-formation processes in the past.

Thus, different kinds of fossils found in the frozen sediments complement each other in their paleoecological implications. Combined with the traditional palynological analysis and with a complex of sedimentary research (mineralogical, geochemical, and isotopic studies, detailed facies and cryolithological characterisation), they build the base for the most complete insight into the past environment. This multidisciplinary research was seen as the main strategy of our field investigations of the Pleistocene sediments in the Lena Delta area.

Besides the search for large mammal bones *in situ* at various field sites and collecting them from the mud flows and on the shore, the main paleontological collecting method was the complex field screening of sediments with the sieves of 1 mm and 0.5 mm mesh. Simple rules (water should never flow over the upper edge of the screen box) allow to avoid contamination of the sample with the organic remains abundant in natural water used for screening. The screen residual is dried, and later all kinds of small fossils are picked up in the laboratory. Although this mesh traps most rodent teeth and bones as well as the mollusc shells, and most of plant and insect fossils, the smallest remains of plants and insects are lost. Since the usage of smaller mesh is too time-consuming, and would essentially restrict the volume of the studied samples, which is not practical in the hard conditions of short Arctic field season, additional small-mesh screening of bulk samples must be conducted in the laboratory.

Below we describe the scope and the main features of the two main paleontological collections obtained in 1998 - large bones and screened samples.

5.7.2 Collection of large mammal bones

One of the earliest finds of almost complete mammoth carcasses (the "Adams' Mammoth" found in 1799) came from the thawing cliffs of the Bykovsky Peninsula. In the recent years this Laptev Sea coastal site with its spectacular exposure of the Ice Complex attracted many researchers, partially due to its relatively easy accessibility. However, the total scope of paleontological and paleoecological research, conducted earlier at the Bykovsky Yedoma sections, is absolutely insufficient. For example, despite the well known abundance of fossil mammal bones in the deposits of Bykovsky Ice Complex, there was no purposeful, systematic, and professional collecting at all. Almost every Quaternary geologist who worked at the Mamontovy Khayata cliff, or at the adjacent Yedoma of the Muostakh Island, used to find some bones *in situ* (Solomatin, 1965; Ivanov and Katasonova, 1979, Tomirdiaro et al., 1984, Kunitsky, 1989). The latter author mentioned a find of complete hare skull in the upper layers of the Mamontovy Ice Complex, and also indicated a bone-bearing horizon immediately above an autochthonous peat layer in the Muostakh Island section. A single mammoth bone has been successfully used for radiocarbon dating (Tomirdiaro et al., 1984), but all the rest of more than two dozens of 14C dates have been obtained from plant material (peat, wood and grass roots). No attempt of comprehensive taxonomic and paleoecological review of fossil mammals from Bykovsky is known in the literature.

In 1998, we were able to collect at the Bykovsky Peninsula more than 600 bones. Typically for permafrost regions, where fossil bones in summer rapidly emerge from frozen sediment and are delivered to the cliff foot by mud flows, most bones come from the shore and shallow coastal bars, mainly in the area of the Mamontovy Khayata cliff, and another site NW of it, provisionally called "the Holocene Shore". However, rather large amount of bones (145) was collected at the Mamontovy Khayata exposure itself. Among them, about 20 bones (location group "a") were discovered strictly *in situ* in the frozen silts and sands, and about 80 bones were found in the mud flows; the initial stratigraphic position of the latter could be reconstructed more or less precisely (location group "b"). About 30 bones, listed under the last group, were found on the surface of fresh mud flows evidently related to certain baidzherakhs, or their closely arranged groups, so the original position of these bones can be estimated within 2-4 meters of the baidzherakh height. The other bones, listed under the group "b", were found (sometimes in rather high concentrations) on the mud flows related to large exposed parts of the cliff, usually at the base of its upper steep part. The areas of these concentrations are labelled here as "bone fields"; the possible altitude range of the original position of bones was usually estimated between the height of their occurrence (minimum) and the height of the cliff in this particular area (maximum). The bones referred to the location type "c" have been found within the Mamontovy Khayata cliff, but their exact position remains unknown.

Compared with the bone collections from the other Ice Complex sites, even such well known and studied as Duvannyy Yar at the Kolyma River, the share of bones found *in situ* or in more or less certain position, is very high in the Mamontovy Khayata collection. The best characterised is the middle part of the section, from about 10 to 25 m a.s.l. (Figure 5-9 a-c). These finds provide sufficient material for rather detailed radiocarbon and bone isotopic analyses. An indirect representation of fossils, coming from the least accessible upper 15-20 m of the cliff (in the places of its maximum height) can most likely be found in the bone fields "Q", "L", and "R". The lower 10 m of the cliff, however, remained covered with multi-year mud accumulations, so the bones originally coming from this part of the section can potentially be found on the shore only (in the rewashed condition).

Nearly 300 bones (group "d") were collected at the Mamontovy Khayata shore and on the more or less adjacent shallow bars emerging during the lower sea level conditions. About 150 bones were picked up at the "Holocene Shore" (group "e"). Finally, a few dozens of bones come from the other sites on the Bykovsky Peninsula (mostly NW from the Mamontovy Khayata), and a few specimens have been delivered from other locations in the Lena Delta (group "f").

The preservation of bones found within the Mamontovy Khayata section is typical for the Ice Complex sites. Some bones look exclusively fresh, almost white coloured, only slightly different from modern bones found in tundra. The surface coloration of the other bones may vary from light grey and pale yellow to reddish-brown, but inside (when broken) these bones are also very freshly looking. The bones collected from the shore are in general more altered and can be more weathered. The most remarkable difference in preservation was observed between the bones collected in the Mamontovy Khayata and at the "Holocene Shore". The bones from the latter site are in general of much darker colour and look more mineralised. That can be explained by an assumption that these bones have not come straight from the Ice Complex (although it seems to be present at the bottom of this exposure), but together with the parts of Ice Complex were "reworked" into taberal sediments with a different geochemical environment which eventually altered the bone appearance.

No fossil bones with evidently more "ancient" preservation, typical for Early-Middle Pleistocene sediments, can be seen in the 1998 collection.

Table 5-6: Preliminary list of vertebrate taxa identified in the Bykovsky Peninsula collection.

AVES - birds*)
- Order Gaviiformes
  - *Gavia arctica* (blackcraw diver)
- Order Anseriformes
  - *Anas acuta* (duck)
  - *Anser fabalis* (goose)
  - *Cygnus bewickii* (tundra swan)

MAMMALIA - mammals
- Order Lagomorpha
  - *Lepus cf. tanaiticus* Gur. (Pleistocene hare)
- Order Rodentia
  - Microtinae gen. (Voles and lemmings)
- Order Cetacea
  - *Delphinapterus leucas* ? (White whale, modern)
- Order Carnivora
  - *Canis sp.* (wolf ?)
  - *Alopex sp.* ? (Arctic fox ?)
  - *Martes sp.* (marten)
  - *Panthera spelaea* (Gold.) (Pleistocene "lion")
  - Carnivora gen. (unidentified carnivores)
- Order Pinnipedia
  - Phocidae gen. (seals)**)
- Order Proboscidea
  - *Mammuthus primigenius* (Blum.) (woolly mammoth)
- Order Perissodactyla
  - *Equus caballus* L. (Pleistocene horse)
- Order Artiodactyla
  - *Alces sp.*? (moose ?)
  - *Rangifer tarandus* (L.) (reindeer)
  - *Ovibos sp.* or *Alces sp.* (muskox or reindeer)
  - *Ovibos sp.* (muskox)
  - Bovidae gen. ***)
  - *Bison priscus* (Boj.) (Pleistocene bison)

Mammalia gen. ****)

*) Birds identified by A. Karkhu.

**) A few seal bones were found on the shore and bars only, so they are assumed to belong to modern animals. The species identification is pending, but it can be supposed that the bones are from any of two seal species currently known in these waters - ringed seal, *Pusa hispida* (Schreb) and bearded seal, *Erignathus barbatus* (Erxl.).

***) Bovidae gen. indicate the bones belonging either to a small bison or to a musk-ox and requiring further investigation.

****) Mammalia gen. - non- identifiable fragments of bones of large mammals

Summarised taxonomic composition of the Bykovsky Peninsula collection is presented in Table 5-6. In general, it is rather typical for all known Ice Complex sites in Northeast Siberia. The main dominants of the collection are woolly mammoth, horse, bison, and reindeer. The samples from the three main location categories - the Mamontovy Khayata cliff (a+b+c), Mamontovy Khayata shore (d) and the Holocene Shore (e) reveal only minor variations between them. One immediate conclusion is that the so-called "Holocene Shore" (see Figure 5-1, outcrop "Mamontovy Bysagasa) sample does not represent the Holocene fauna, except a few modern bones of marine mammals - this is a rather typical Pleistocene assemblage. The cliff sample has a higher share of mammoth and hare bones and a lower share of horse and bison bones as compared with the two shore samples. The cliff sample does not include bones of modern seals and whales encountered on the shore. The latter feature is quite obvious, as well as more rear occurrence of small hare bones on the shore. It is more difficult to explain a relatively low percentage of horse and bison bones within the cliff against that of the shore samples.

One remarkable feature of the 1998' collection as a whole is that it was designed as the most complete registration of all bones and fragments encountered. Some objective collecting biases, however, seems inevitable. Smaller bones, such as isolated teeth, or small carpal bones, are much easier to be detected on the shore, where they have been washed and cleaned, than among the mess of the mud flows on the exposure. This is illustrated by the proportion of horse bones of various size, collected respectively at the Mamontovy Khayata cliff and on the shore in front of it:

	Cliff	Shore
LARGE: Large limb bones, shoulder blades, pelvic bones	10	16
MEDIUM: metapodials, phalanx, astragals, calcanei, vertebrae, mandibles, maxillae	4	23
SMALL: isolated teeth, small carpal bones	2	24

This evident trend is opposite for even smaller bones of hares and rodents, which are detected by a close-sight examination of baydzherakhs´ walls, and have much fewer chances to be noticed on the shore.

Thus, collecting at each of the location types has its own biases, and it is hard to decide at the moment which sample is preferable for statistic comparisons with the other localities. It seems most reasonable to rely upon the features common for all our samples.

The most remarkable among those features is a clear dominance of mammoth fossils in all the samples. The mammoth share is as high as nearly 40% in both cliff and shore samples. It is not as high as in the Berelyokh Mammoth Cemetery, where mammoth bones comprise 99% of almost 9,000 fossils collected, but it seems higher than in the other Ice Complex sites in the Coastal Lowlands. For example, the multi-year collection from the mentioned Duvannyy Yar Ice Complex site (633 specimens) is dominated by horse (55%), bison (18%), and reindeer (10%), while mammoth comprise only 3.5% of the sample. The latter sample, however, cannot be used for any statistic comparisons, since, unlike Mamontovy Khayata, there were certainly no comprehensive recordings of all the bones found, and in particular, the mammoth share was seriously underestimated (most mammoth limb bones have not been counted).

In the cliff sample, the second place after mammoth is shared by reindeer and hare. Only these three species were found in strict *in situ* positions. It cannot be excluded that some reindeer bones found on the mud flows, can belong to living animals, shed antlers especially (this is evidently the case in the shore sample), but most of them are certainly fossil. It is not clear at the moment whether the bird bones found within the cliff (a goose and a duck) are fossil or modern. It is normal that the animals which are less numerous in natural communities (e.g., carnivores) or are rather rare in the whole collection (e.g., musk-ox), are not represented in the cliff sample, but in the shore samples only.

The carnivore sample in the shore collection is hardly representative (7 bones). It includes a large extinct Pleistocene lion-like cat, *Panthera spelaea* (Gold.), some middle-sized marten, and possibly Arctic fox. Only four bones definitely belong to musk-ox. It should be noted that the presence of deer other than reindeer (moose, *Alces*, and red deer, *Cervus*, listed in some Yedoma assemblages) is not definitely documented in the Bykovsky collection. The same is true in regard of woolly rhino.

Collection of large mammal bones from the Bykovsky Peninsula needs further investigation, first of all, concerning morphological characters of the most abundant species, such as woolly mammoth, bison, and horse.

Table 5-7: Summarised composition of osteological collection from the Bykovsky Peninsula and the Lena Delta area, 1998.

	Total - 636 bones		Mamontovy Khayata Cliff - 145 bones		Mamontovy - shore and bars - 290 bones		Holocene shore - 158 bones		Other sites - 43 bones	
	N	%	N	%	N	%	N	%	N	%
Birds	4	0,6	2	1,4	1	0,3	1	0,6	0	0,0
Recent marine mammals	13	2,0	0	0,0	8	2,8	5	3,2	0	0,0
Carnivores	7	1,1	0	0,0	2	0,7	3	1,9	2	4,7
Hare	39	6,1	22	15,2	12	4,1	2	1,3	3	7,0
Mammoth	229	36,0	60	41,4	113	39,0	43	27,2	13	30,2
Horse	119	18,7	16	11,0	63	21,7	36	22,8	4	9,3
Reindeer	95	14,9	22	15,2	37	12,8	24	15,2	12	27,9
Bison	82	12,9	6	4,1	35	12,1	33	20,9	8	18,6
Musk-ox	4	0,6	0	0,0	3	1,0	1	0,6	0	0,0
Other Artiodactyls (unident.)	5	0,8	3	2,1	1	0,3	1	0,6	0	0,0
Unident.mammals	39	6,1	14	9,7	15	5,2	9	5,7	1	2,3
Total	636	100,0	145	100,0	290	100,0	158	100,0	43	100,0

5.7.3 Collection of screened samples for small fossils

Besides a very restricted accessibility of most parts of the Mamontovy Khayata frozen cliff, a real problem was to take rather large samples for screening. Exposed ground ice melts out faster than the ground columns between the ice wedges, and the conic remnants of these columns (thermokarst mounds, or "baydzherakhs") represent the main potential area for the study of undisturbed beds with fossils. Baydzherakhs have rather steep slopes, and the thawed material usually flaws down to the base and gets mixed with the mud flows; only a thin thawed layer can be found on the baydzherakh slope in a more or less intact position. The volume of this thawed sediment is normally not enough for mass screening; otherwise, the sediment must be taken from a larger surface, which decrease the stratigraphic resolution of sampling. One practical solution was to take larger samples for screening from the peak of a baydzherakh, where the thaw is deeper, but more sediment remains in place for some time. We believe, however, that some technique of extracting frozen sediment blocks should be developed, but in 1998 we were unable to try that.

Despite this problem, we tried to keep an average size of a screened sample not less than 30-40 kg, but for easier accessible sites it was greater. Totally, about 50 samples from the Pleistocene and Holocene deposits of the Bykovsky Peninsula have been screened during the field work in 1998 (Table A5-6, appendix). They have two kinds of field indexes - R (for "rodents") and B (for "beetles"); the difference is that they were screened with the sieves of 1.0 mm and 0.5 mm mesh respectively, but small bones can occur in the "B" samples, and insect remains are common in the "R" samples as well.

As usual, the screened samples contain various organic remains, both of plant and animal origin. Plant macrofossils include abundant unidentifiable fragments (plant detritus), including small twigs and roots, moss stems, but also seeds and fruits, and sometimes even small leaves. Among animal fossils, small bones and mollusc shells, often fragmented, can be found, as well as some small crustaceans (ostracodes, daphnia), but the most numerous are fossils of various insects: bugs (Heteroptera), ants and ichneumons (Hymenoptera), larvae and puparia of flies (Diptera), larvae of caddis-flies (Trichoptera), and beetles (Coleoptera). The latter group is most common, and at the same time the most identifiable, so fossil beetles form the main base of paleoecological analysis.

The preservation of insect fossils in most samples is very good. Quite common, several parts of exoskeleton of one animal are found in natural attachment to each other; sometimes, microscopic scales and hair are not only preserved on the beetles' elytra (wing-cases), but retain their life coloration. All that indicates primary, autochthonous character of the fossil sites.

Abundance of insect fossils vary from sample to sample; usually it is not less than a few dozens, but may reach a few hundreds. Statistical treatment of insect samples is based, however, not on the number of specimens, but on the minimum number of individuals. The latter is calculated from the number of the most frequent skeletal elements, which cannot belong to one animal. Not all skeletal elements can be resolved up to a species level.

Taxonomic identification, requiring detailed comparison of fossil fragments with the key collections of modern and fossil animals, is the core of paleoentomological study; this laborious work with extensive 1998' collection is currently in progress. It should be followed by ecological analysis of fossil assemblages, based on modern distribution and ecological requirements of the extant species. Experience of previous studies of the Pleistocene insects of north-east Siberia (Kiselyov, 1981; Kuzmina, 1989) suggests the recognition of about 10 ecological groups, such as tundra xerophiles, tundra mesophiles, steppe inhabitants, aquatic and riparian species, species related to trees, shrubs, or certain meadow plants, etc. Relative numbers of individuals, referred to these ecological groups, allow to compare fossil assemblages and reveal the trends in environmental change along the geological section.

A very preliminary evaluation of fossil insect assemblages from the Bykovsky Peninsula Ice Complex shows that they are generally similar to the previously studied insect faunas of the Coastal Lowlands of north-eastern Yakutia and belong to characteristic assemblages of the Late Pleistocene Arctic, which have no complete modern analogues. Dominated by the inhabitants of various tundra biotopes, they are marked by significant participation of steppe and dry grassland species. On the other hand, the Bykovsky Peninsula insect faunas demonstrate some distinctions from those of earlier studied mainland locations, and these feature may imply a kind of past natural zonation. Finally, it seems evident from the preliminary study that the sequence of insect faunas obtained through the Bykovsky Ice Complex section will reveal some interesting trends in the evolution of the vegetation and climate during the Late Pleistocene.

Lithological and facial condition of the Ice Complex sediments on Bykovsky Peninsula seemed quite appropriate for concentration of small mammal fossils, especially in the beds enriched with sandy material and including gravel particles. In part, this is confirmed by the presence of rodent teeth and bones in several screened samples. However, these samples include only few isolated teeth, and no sample is sufficient for statistical evaluation, on which the study of fossil small mammals is based. Thus, the general result of sampling for small mammals is unsatisfactory. We think that it can be explained mainly by insufficient volume of screened sediment. Most commonly, good small mammal samples are obtained by screening hundreds of kilograms of sediment, not dozens, like it was in our case. This negative experience clearly shows that the problem of frozen sediment extracting for screening must be considered very seriously for future research.

5.8 References

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5.9 Appendix

Table A5-1: List of water and ice samples collected on Bykovsky Peninsula during field season 1998.

				Isotopes				Chemistry		
Nr.	date	sample	type	18O	2H	3H	10 Be	anion /cation	pH	LF
1	24.07.98	BYK 97/01 HM	SP	X	X	X	-	X	5.78	16.1
2	24.07.98	BYK 97/02 HM	SP	X	X	X	-	X	6.18	14.5
3	25.07.98	BYK 99/01 HM	RW	X	X	X	-	X	3.79	21.3
4	26.07.98	MKh-3-I-1	IW	X	X	-	-	X	-	461
5	26.07.98	MKh-3-I-2	IW	X	X	-	-	-	-	-
6	26.07.98	MKh-3-I-3	IW	X	X	-	-	-	8.24	265
7	26.07.98	MKh-3-I-4	IW	X	X	-	-	-	8.23	137
8	26.07.98	MKh-3-I-5	IW	X	X	-	-	-	-	-
9	26.07.98	MKh-3-I-6	IW	X	X	-	-	X	-	181
10	26.07.98	MKh-3-I-7	IW	X	X	-	-	-	8.68	127
11	26.07.98	MKh-3-I-8	IW	X	X	-	-	-	-	-
12	26.07.98	MKh-3-I-9	IW	X	X	-	-	-	8.27	136
13	26.07.98	MKh-3-I-10	IW	X	X	-	-	-	8.07	186
14	26.07.98	MKh-3-I-11	IW	X	X	-	-	X	-	192
15	26.07.98	MKh-3-I-12	IW	X	X	-	-	-	-	-
16	26.07.98	MKh-3-I-13	IW	X	X	-	-	-	8.35	182
17	26.07.98	MKh-3-I-14	IW	X	X	-	-	-	-	-
18	26.07.98	MKh-3-I-15	IW	X	X	-	-	-	8.39	187
19	26.07.98	MKh-3-I-16	IW	X	X	-	-	X	8.13	203
20	26.07.98	MKh-3-I-17	IW	X	X	-	-	-	8.35	222
21	26.07.98	MKh-3-I-18	IW	X	X	-	-	-	-	
22	26.07.98	MKh-3-I-19	IW	X	X	-	-	-	8.45	163
23	26.07.98	MKh-3-I-20	IW	X	X	-	-	X	-	184
24	26.07.98	MKh-3-I-21	IW	X	X	-	-	-	7.76	213
25	26.07.98	MKh-3-I-22	IW	X	X	-	-	-	-	-
26	26.07.98	MKh-3-I-23	IW	X	X	-	-	-	8.06	182
27	26.07.98	MKh-3-I-24	IW	X	X	-	-	-	-	-
28	26.07.98	MKh-3-I-25	IW	X	X	-	-	-	7.98	194
29	26.07.98	MKh-3-I-26	IW	X	X	-	-	X	7.23	156
30	26.07.98	MKh-3-I-27	IW	X	X	-	-	-	8.29	166
31	26.07.98	MKh-3-I-28	IW	X	X	-	-	-	-	-
32	26.07.98	MKh-3-I-29	IW	X	X	-	-	-	7.65	164
33	26.07.98	MKh-3-I-30	IW	X	X	-	-	X	-	164
34	26.07.98	MKh-3-I-31	IW	X	X	-	-	X	7.67	138
35	26.07.98	MKh-3-I-32	IW	X	X	-	-	-	-	149
36	26.07.98	MKh-3-I-33	IW	X	X	-	-	-	8.06	167
37	26.07.98	MKh-3-I-34	IW	X	X	-	-	-	-	-
38	26.07.98	MKh-3-I-35	IW	X	X	-	-	-	7.86	141
39	26.07.98	MKh-3-I-36	IW	X	X	-	-	X	-	-

Table A5-1: continuation

				Isotopes				Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
40	26.07.98	MKh-3-I-37	IW	X	X	-	-	-	7.58	150
41	26.07.98	MKh-3-I-38	IW	X	X	-	-	-	-	-
42	26.07.98	MKh-3-I-39	IW	X	X	-	-	-	8.11	176
43	26.07.98	MKh-3-I-40	IW	X	X	-	-	-	-	-
44	26.07.98	MKh-3-I-41	IW	X	X	-	-	X	7.51	142
45	26.07.98	MKh-3-I-42	IW	X	X	-	-	-	8.29	140
46	26.07.98	MKh-3-I-43	IW	X	X	-	-	-	8.39	203
47	26.07.98	MKh-3-I-44	IW	X	X	-	-	-	-	137
48	26.07.98	MKh-3-I-45	IW	X	X	-	-	-	7.50	151
49	26.07.98	MKh-3-I-46	IW	X	X	-	-	X	7.65	201
50	26.07.98	MKh-3-I-47	IW	X	X	-	-	-	7.08	133
51	26.07.98	MKh-3-I-48	IW	X	X	-	-	-	-	-
52	26.07.98	MKh-3-I-49	IW	X	X	-	-	-	7.79	170
53	26.07.98	MKh-3-I-50	IW	X	X	-	-	-	-	-
54	26.07.98	MKh-3-I-51	IW	X	X	-	-	X	8.29	151
55	26.07.98	MKh-3-I-52	IW	X	X	-	-	-	-	155
56	26.07.98	MKh-3-I-53	IW	X	X	-	-	-	7.01	142
57	26.07.98	MKh-3-I-54	IW	X	X	-	-	-	-	
58	26.07.98	MKh-3-I-55	IW	X	X	-	-	-	7.39	143
59	26.07.98	MKh-3-I-56	IW	X	X	-	-	X	7.39	174
60	26.07.98	MKh-3-I-57	IW	X	X	-	-	-	7.67	387
61	26.07.98	MKh-3-I-58	IW	X	X	-	-	-	7.79	528
62	26.07.98	MKh-3-I-59	IW	X	X	-	-	-	7.68	203
63	26.07.98	MKh-3-I-60	IW	X	X	-	-	-	-	-
64	26.07.98	MKh-3-I-61	IW	X	X	-	-	-	7.56	307
65	26.07.98	MKh-3-I-62	IW	X	X	-	-	X	7.91	187
66	26.07.98	MKh-3-I-63	IW	X	X	-	-	-	7.41	187
67	26.07.98	MKh-3-I-64	IW	X	X	-	-	-	-	-
68	26.07.98	MKh-3-I-65	IW	X	X	-	-	-	7.51	221
69	26.07.98	MKh-3-I-66	IW	X	X	-	-	-	-	-
70	26.07.98	MKh-3-I-67	IW	X	X	-	-	-	8.19	191
71	26.07.98	MKh-3-I-68	IW	X	X	-	-	X	-	-
72	26.07.98	MKh-3-I-69	IW	X	X	-	-	-	-	-
73	26.07.98	MKh-3-I-70	IW	X	X	-	-	-	-	-
74	26.07.98	MKh-3-I-71	IW	X	X	-	-	-	8.69	184
75	26.07.98	MKh-3-I-72	IW	X	X	-	-	X	8.87	179
76	26.07.98	MKh-3-I-73	IW	X	X	-	-	-	8.06	211
77	26.07.98	MKh-3-I-74	IW	X	X	-	-	-	-	-
78	26.07.98	MKh-3-I-75	IW	X	X	-	-	-	7.75	233
79	26.07.98	MKh-3-I-76	IW	X	X	-	-	-	-	-
80	26.07.98	MKh-3-I-77	IW	X	X	-	-	-	8.32	148
81	26.07.98	MKh-3-I-78	IW	X	X	-	-	X	-	-
82	26.07.98	MKh-3-I-79	IW	X	X	-	-	-	8.12	200

Table A5-1: continuation

				Isotopes				Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
83	26.07.98	MKh-3-I-80	IW	X	X	-	-	-	-	-
84	26.07.98	MKh-3-I-81	IW	X	X	-	-	-	7.99	166
85	26.07.98	MKh-3-I-82	IW	X	X	-	-	X	-	-
86	26.07.98	MKh-3-I-83	IW	X	X	-	-	-	7.86	192
87	26.07.98	MKh-3-I-84	IW	X	X	-	-	-	-	-
88	26.07.98	MKh-3-I-85	IW	X	X	-	-	-	7.60	221
89	26.07.98	MKh-3-I-86	IW	X	X	-	-	-	-	-
90	26.07.98	MKh-3-I-87	IW	X	X	-	-	X	7.76	201
91	26.07.98	MKh-3-I-88	IW	X	X	-	-	-	-	-
92	26.07.98	MKh-3-I-89	IW	X	X	-	-	-	7.79	285
93	26.07.98	MKh-3-I-90	IW	X	X	-	-	-	-	-
94	26.07.98	MKh-3-I-91	IW	X	X	-	-	-	7.67	620
95	26.07.98	MKh-3-I-92	IW	X	X	-	-	-	-	-
96	26.07.98	MKh-3-I-93	IW	X	X	-	-	-	8.17	295
97	26.07.98	MKh-3-I-94	IW	X	X	-	-	-	-	-
98	26.07.98	MKh-3-I-95	IW	X	X	-	-	-	8.27	205
99	26.07.98	MKh-3-I-96	IW	X	X	-	-	-	-	-
100	27.07.98	MKh-3-I-97	IW	X	X	-	-	-	7.93	101
101	27.07.98	MKh-3-I-98	IW	X	X	-	-	-	-	-
102	27.07.98	MKh-3-I-99	IW	X	X	-	-	-	7.88	154
103	27.07.98	MKh-3-I-100	IW	X	X	-	-	-	-	-
104	27.07.98	MKh-3-I-101	IW	X	X	-	-	-	7.31	149
105	27.07.98	MKh-3-I-102	IW	X	X	-	-	-	-	-
106	27.07.98	MKh-3-I-103	IW	X	X	-	-	-	7.65	142
107	27.07.98	MKh-3-I-104	IW	X	X	-	-	-	-	-
108	27.07.98	MKh-3-I-105	IW	X	X	-	-	-	7.28	139
109	27.07.98	MKh-3-I-106	IW	X	X	-	-	-	-	-
110	27.07.98	MKh-3-I-107	IW	X	X	-	-	-	7.33	186
111	27.07.98	MKh-3-I-108	IW	X	X	-	-	-	-	-
112	27.07.98	MKh-3-I-109	IW	X	X	-	-	-	7.44	172
113	27.07.98	MKh-3-I-110	IW	X	X	-	-	-	-	-
114	27.07.98	MKh-3-I-111	IW	X	X	-	-	-	7.13	161
115	27.07.98	MKh-3-I-112	IW	X	X	-	-	-	-	-
116	27.07.98	MKh-3-I-113	IW	X	X	-	-	-	7.59	246
117	27.07.98	MKh-3-I-114	IW	X	X	-	-	-	-	-
118	27.07.98	MKh-3-I-115	IW	X	X	-	-	-	7.38	292
119	27.07.98	MKh-3-I-116	IW	X	X	-	-	-	-	-
120	27.07.98	MKh-3-I-117	IW	X	X	-	-	-	7.94	289
121	27.07.98	MKh-3-I-118	IW	X	X	-	-	-	-	-
122	27.07.98	MKh-3-I-119	IW	X	X	-	-	-	7.80	210
123	27.07.98	MKh-97-1-I1	SP	X	X	X	-	X	6.70	6.8
124	27.07.98	MKh-4-I-1	SW	X	X	X	-	X	6.74	95
125	27.07.98	MKh-4-I-2	SW	X	X	X	-	X	7.31	205

Table A5-1: continuation

						Isotopes		Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
126	27.07.98	MKh-4-I-3	SW	X	X	X	-	X	7.80	381
127	27.07.98	MKh-4-I-4	SW	X	X	X	-	X	7.12	92
128	28.07.98	MKh-3-I-120	TI	X	X	-	-	-	-	-
129	28.07.98	MKh-3-I-121	TI	X	X	-	-	-	7.86	227
130	28.07.98	MKh-3-I-122	TI	X	X	-	-	-	-	-
131	28.07.98	MKh-3-I-123	TI	X	X	X	-	-	8.24	169
132	28.07.98	MKh-3-I-124	TI	X	X	-	-	-	-	-
133	28.07.98	MKh-3-I-125	TI	X	X	-	-	-	7.72	728
134	28.07.98	MKh-3-I-126	TI	X	X	-	-	-	-	-
135	28.07.98	MKh-3-I-127	TI	X	X	X	-	-	7.90	396
136	28.07.98	MKh-3-I-128	TI	X	X	-	-	-	-	-
137	28.07.98	MKh-3-I-129	TI	X	X	-	-	-	7.88	512
138	28.07.98	MKh-3-I-130	TI	X	X	-	-	-	-	-
139	28.07.98	MKh-3-I-131	TI	X	X	X	-	-	7.74	930
140	28.07.98	MKh-3-I-132	TI	X	X	-	-	-	-	-
141	28.07.98	MKh-3-I-133	TI	X	X	-	-	-	7.33	3090
142	28.07.98	MKh-3-I-134	TI	X	X	-	-	-	-	-
143	28.07.98	MKh-3-I-135	TI	X	X	-	-	-	8.14	200
144	28.07.98	MKh-3-I-136	TI	X	X	-	-	-	-	-
145	28.07.98	MKh-3-I-137	TI	X	X	-	-	-	8.00	717
146	28.07.98	MKh-3-I-138	TI	X	X	-	-	-	-	-
147	28.07.98	MKh-3-I-139	TI	X	X	-	-	-	7.70	1250
148	29.07.98	BYK 99/02 HM	RW	X	X	X	-	X	4.71	19
149	29.07.98	BYK 98/01 HM	GW	X	X	X	-	-	5.75	34
150	24.07.98	BYK 97-003-1 AD	SP	X	X	X	-	-	6.50	13.5
151	24.07.98	BYK 97-004-1 AD	SP	X	X	X	-	-	6.05	5.6
152	24.07.98	BYK 97-004-2 AD	SP	X	X	X	-	-	6.36	15
153	20.07.98	Ice cave in Tiksi	IW	X	X	X	-	-	6.20	35
154	30.07.98	MKh-5-I-1	IW	X	X	-	-	X	6.91	963
155	30.07.98	MKh-5-I-2	IW	X	X	-	-	-	-	-
156	30.07.98	MKh-5-I-3	IW	X	X	X	-	-	8.10	81
157	30.07.98	MKh-5-I-4	IW	X	X	-	-	-	-	68
158	30.07.98	MKh-5-I-5	IW	X	X	-	-	-	8.39	63
159	30.07.98	MKh-5-I-6	IW	X	X	X	-	X	-	78
160	30.07.98	MKh-5-I-7	IW	X	X	-	-	-	8.38	71
161	30.07.98	MKh-5-I-8	IW	X	X	-	-	-	-	76
162	30.07.98	MKh-5-I-9	IW	X	X	X	-	-	8.57	116
163	30.07.98	MKh-5-I-10	IW	X	X	-	-	-	-	-
164	30.07.98	MKh-5-I-11	IW	X	X	-	-	X	8.39	147
165	30.07.98	MKh-5-I-12	IW	X	X	X	-	-	-	-
166	30.07.98	MKh-5-I-13	IW	X	X	-	-	-	8.33	103
167	30.07.98	MKh-5-I-14	IW	X	X	-	-	-	-	-
168	30.07.98	MKh-5-I-15	IW	X	X	-	-	-	8.67	105

Table A5-1: continuation

Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
					Isotopes			Chemistry		
169	30.07.98	MKh-5-I-16	IW	X	X	-	-	X	-	-
170	30.07.98	MKh-5-I-17	IW	X	X	-	-	-	8.76	97
171	30.07.98	MKh-5-I-18	IW	X	X	X	-	-	-	-
172	30.07.98	MKh-5-I-19	IW	X	X	-	-	-	8.31	76
173	30.07.98	MKh-5-I-20	IW	X	X	-	-	-	-	-
174	30.07.98	MKh-5-I-21	IW	X	X	X	-	X	8.94	132
175	30.07.98	MKh-5-I-22	IW	X	X	-	-	-	-	-
176	30.07.98	MKh-5-I-23	IW	X	X	-	-	-	8.31	88
177	30.07.98	MKh-5-I-24	IW	X	X	-	-	-	-	-
178	30.07.98	MKh-5-I-25	IW	X	X	-	-	-	8.01	101
179	30.07.98	MKh-5-I-26	IW	X	X	-	-	X	-	-
180	30.07.98	MKh-5-I-27	IW	X	X	X	-	-	8.06	131
181	30.07.98	MKh-5-I-28	IW	X	X	-	-	-	-	-
182	30.07.98	MKh-5-I-29	IW	X	X	-	-	-	8.27	116
183	30.07.98	MKh-5-I-30	IW	X	X	X	-	-	-	-
184	30.07.98	MKh-5-I-31	IW	X	X	-	-	X	7.63	107
185	30.07.98	MKh-5-I-32	IW	X	X	-	-	-	-	-
186	30.07.98	MKh-5-I-33	IW	X	X	-	-	-	8.19	89
187	30.07.98	MKh-5-I-34	IW	X	X	-	-	-	-	-
188	30.07.98	MKh-5-I-35	IW	X	X	-	-	-	7.79	89
189	30.07.98	MKh-5-I-36	IW	X	X	X	-	X	8.10	90
190	30.07.98	MKh-5-I-37	IW	X	X	-	-	-	7.87	96
191	30.07.98	MKh-5-I-38	IW	X	X	-	-	-	-	-
192	30.07.98	MKh-5-I-39	IW	X	X	-	-	-	8.63	77
193	30.07.98	MKh-5-I-40	IW	X	X	-	-	-	-	-
194	30.07.98	MKh-5-I-41	IW	X	X	-	-	X	7.92	88
195	30.07.98	MKh-5-I-42	IW	X	X	X	-	-	-	-
196	30.07.98	MKh-5-I-43	IW	X	X	-	-	-	8.00	67
197	30.07.98	MKh-5-I-44	IW	X	X	-	-	-	-	-
198	30.07.98	MKh-5-I-45	IW	X	X	X	-	-	7.87	80
199	30.07.98	MKh-5-I-46	IW	X	X	-	-	X	-	-
200	30.07.98	MKh-5-I-47	IW	X	X	-	-	-	7.80	97
201	30.07.98	MKh-5-I-48	IW	X	X	X	-	-	-	-
202	30.07.98	MKh-5-I-49	IW	X	X	-	-	-	8.10	107
203	30.07.98	MKh-5-I-50	IW	X	X	-	-	-	-	-
204	30.07.98	MKh-5-I-51	IW	X	X	-	-	X	8.27	144
205	30.07.98	MKh-5-I-52	IW	X	X	-	-	-	-	-
206	30.07.98	MKh-5-I-53	IW	X	X	-	-	-	7.63	93
207	30.07.98	MKh-5-I-54	IW	X	X	X	-	-	-	-
208	30.07.98	MKh-5-I-55	IW	X	X	-	-	-	7.88	110
209	30.07.98	MKh-5-I-56	IW	X	X	-	-	X	-	-
210	30.07.98	MKh-5-I-57	IW	X	X	-	-	-	8.22	96
211	30.07.98	MKh-5-I-58	IW	X	X	-	-	-	-	-

Table A5-1: continuation

				Isotopes				Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
212	30.07.98	MKh-5-I-59	IW	X	X	-	-	-	8.16	127
213	30.07.98	MKh-5-I-60	IW	X	X	X	-	-	-	-
214	30.07.98	MKh-5-I-61	IW	X	X	-	-	X	8.01	117
215	30.07.98	MKh-5-I-62	IW	X	X	-	-	-	-	-
216	30.07.98	MKh-5-I-63	IW	X	X	-	-	-	8.34	79
217	30.07.98	MKh-5-I-64	IW	X	X	-	-	-	-	-
218	30.07.98	MKh-5-I-65	IW	X	X	-	-	-	8.53	191
219	30.07.98	MKh-5-I-66	IW	X	X	X	-	-	-	-
220	30.07.98	MKh-5-I-67	IW	X	X	-	-	X	8.10	126
221	30.07.98	MKh-5-I-68	IW	X	X	X	-	-	-	-
222	30.07.98	MKh-5-I-69	IW	X	X	X	-	-	7.81	65
223	30.07.98	MKh-5-I-70	IW	X	X	-	-	-	-	-
224	30.07.98	MKh-5-I-71	IW	X	X	-	-	X	8.12	64
225	30.07.98	MKh-5-I-72	IW	X	X	X	-	-	-	-
226	30.07.98	MKh-5-I-73	IW	X	X	-	-	-	8.40	102
227	30.07.98	MKh-5-I-74	IW	X	X	-	-	-	-	-
228	30.07.98	BYK-H-I-1	IW	X	X	X	-	-	7.75	219
229	30.07.98	BYK-H-I-2	IW	X	X	X	-	-	-	-
230	30.07.98	BYK-H-I-3	IW	X	X	X	-	-	5.91	52
231	30.07.98	BYK-H-I-4	IW	X	X	X	-	-	-	-
232	30.07.98	BYK-H-I-5	IW	X	X	X	-	-	5.94	36
233	30.07.98	BYK-H-I-6	IW	X	X	X	-	-	-	-
234	30.07.98	BYK-H-I-7	IW	X	X	X	-	-	5.94	67
235	30.07.98	BYK-H-I-8	IW	X	X	X	-	-	-	-
236	30.07.98	BYK-H-I-9	IW	X	X	X	-	-	5.99	29
237	30.07.98	BYK-H-I-10	IW	X	X	X	-	-	-	-
238	30.07.98	BYK-H-I-11	IW	X	X	X	-	-	6.03	44
239	30.07.98	BYK-H-I-12	IW	X	X	X	-	-	-	-
240	30.07.98	BYK-H-I-13	IW	X	X	X	-	-	6.05	31
241	30.07.98	BYK-H-I-14	IW	X	X	X	-	-	-	-
242	30.07.98	BYK-H-I-15	IW	X	X	X	-	-	6.15	46
243	30.07.98	BYK 98/02 HM	GW	X	X	X	-	-	-	39
244	30.07.98	BYK 98/03 HM	GW	X	X	X	-	X	-	50.4
245	31.07.98	BYK 96/01 AD	SW	X	X	X	-	X	-	-
246	31.07.98	MKh-K1-I-3	TI	X	X	-	-	X	6.85	1157
247	31.07.98	MKh-K1-I-4	TI	X	X	-	-	X	7.17	2240
248	31.07.98	MKh-K1-I-5	TI	X	X	-	-	X	6.64	1675
249	31.07.98	MKh-K1-I-6	TI	X	X	X	-	X	7.14	1075
250	31.07.98	MKh-K1-I-9	TI	X	X	-	-	X	6.86	1217
251	31.07.98	MKh-K1-I-10	TI	X	X	-	-	X	6.92	1590
252	31.07.98	MKh-K1-I-11	TI	X	X	-	-	X	7.02	688
253	31.07.98	MKh-K1-I-1	TI	X	X	-	-	X	7.65	300
254	31.07.98	MKh-KK-I-1	IW	X	X	-	-	-	7.27	200

Table A5-1: continuation

						Isotopes		Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
255	31.07.98	MKh-KK-I-2	IW	X	X	-	-	-	-	-
256	31.07.98	MKh-KK-I-3	IW	X	X	-	-	-	-	-
257	31.07.98	MKh-KK-I-4	IW	X	X	-	-	-	-	-
258	31.07.98	MKh-1-I-01-1	IW	X	X	X	-	-	-	-
259	31.07.98	MKh-1-I-01-2	IW	X	X	X	-	-	-	-
260	31.07.98	MKh-1-I-01-3	IW	X	X	X	-	-	-	-
261	31.07.98	MKh-1-I-01-4	IW	X	X	X	-	-	-	-
262	31.07.98	MKh-97-03-1 AD	SP	X	X	X	-	X	7.60	190
263	31.07.98	MKh-97-03-2 AD	SP	X	X	X	-	X	7.02	21
264	31.07.98	MKh-97-03-3 AD	SP	X	X	X	-	X	6.53	11
265	31.07.98	MKh-97-03-4 AD	SP	X	X	X	-	-	-	-
266	01.08.98	Mkh-1-I-02-1	IW	X	X	-	-	X	-	-
267	01.08.98	Mkh-1-I-02-2	IW	X	X	-	-	-	-	-
268	01.08.98	Mkh-1-I-02-3	IW	X	X	-	-	-	7.65	146
269	01.08.98	Mkh-1-I-02-4	IW	X	X	-	-	-	-	-
270	01.08.98	Mkh-1-I-02-5	IW	X	X	-	-	X	-	-
271	01.08.98	Mkh-1-I-02-6	IW	X	X	-	-	X	-	-
272	01.08.98	Mkh-1-I-02-7	IW	X	X	-	-	-	7.66	233
273	01.08.98	Mkh-1-I-02-8	IW	X	X	-	-	-	-	-
274	01.08.98	Mkh-1-I-02-9	IW	X	X	-	-	-	7.67	367
275	01.08.98	Mkh-1-I-02-10	IW	X	X	-	-	X	-	-
276	01.08.98	Mkh-1-I-02-11	IW	X	X	-	-	-	-	-
277	01.08.98	Mkh-1-I-02-12	IW	X	X	-	-	-	-	-
278	01.08.98	Mkh-1-I-02-13	IW	X	X	-	-	-	7.74	258
279	01.08.98	Mkh-1-I-02-14	IW	X	X	-	-	-	-	-
280	01.08.98	Mkh-1-I-02-15	IW	X	X	-	-	X	-	-
281	01.08.98	Mkh-1-I-02-16	IW	X	X	-	-	-	-	-
282	01.08.98	Mkh-1-I-02-17	IW	X	X	-	-	-	-	-
283	01.08.98	Mkh-1-I-02-18	IW	X	X	-	-	-	-	-
284	01.08.98	Mkh-1-I-02-19	IW	X	X	-	-	-	-	-
285	01.08.98	Mkh-1-I-02-20	IW	X	X	-	-	X	-	-
286	01.08.98	Mkh-1-I-02-21	IW	X	X	-	-	X	7.93	210
287	01.08.98	Mkh-1-I-02-22	IW	X	X	-	-	-	-	-
288	01.08.98	Mkh-1-I-02-23	IW	X	X	-	-	-	7.81	291
289	01.08.98	Mkh-1-I-02-24	IW	X	X	-	-	-	-	-
290	01.08.98	Mkh-1-I-02-25	IW	X	X	-	-	X	-	-
291	01.08.98	Mkh-1-I-02-26	IW	X	X	-	-	X	-	-
292	01.08.98	Mkh-1-I-02-27	IW	X	X	-	-	-	7.71	279
293	01.08.98	Mkh-1-I-02-28	IW	X	X	-	-	-	-	-
294	01.08.98	Mkh-1-I-02-29	IW	X	X	-	-	-	7.87	285
295	01.08.98	Mkh-1-I-02-30	IW	X	X	-	-	X	-	-
296	01.08.98	Mkh-1-I-02-31	IW	X	X	-	-	X	7.98	220
297	01.08.98	Mkh-1-I-02-32	IW	X	X	-	-	-	-	-

Table A5-1: continuation

				Isotopes				Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
298	01.08.98	Mkh-1-I-02-33	IW	X	X	-	-	-	8.10	195
299	01.08.98	Mkh-1-I-02-34	IW	X	X	-	-	-	-	-
300	01.08.98	Mkh-1-I-02-35	IW	X	X	-	-	X	-	-
301	01.08.98	Mkh-1-I-02-36	IW	X	X	-	-	X	-	-
302	01.08.98	Mkh-1-I-02-37	IW	X	X	-	-	-	8.11	193
303	01.08.98	Mkh-1-I-02-38	IW	X	X	-	-	-	-	-
304	01.08.98	Mkh-1-I-02-39	IW	X	X	-	-	-	8.06	183
305	01.08.98	Mkh-1-I-02-40	IW	X	X	-	-	X	-	-
306	01.08.98	Mkh-1-I-02-41	IW	X	X	-	-	X	8.01	236
307	01.08.98	Mkh-1-I-02-42	IW	X	X	-	-	-	-	-
308	01.08.98	Mkh-1-I-02-43	IW	X	X	-	-	-	7.78	162
309	01.08.98	Mkh-1-I-02-44	IW	X	X	-	-	-	-	-
310	01.08.98	Mkh-1-I-02-45	IW	X	X	-	-	X	-	-
311	01.08.98	Mkh-1-I-02-46	IW	X	X	-	-	X	-	-
312	01.08.98	Mkh-1-I-02-47	IW	X	X	-	-	-	7.80	156
313	01.08.98	Mkh-1-I-02-48	IW	X	X	-	-	-	-	-
314	01.08.98	Mkh-1-I-02-49	IW	X	X	-	-	-	8.09	327
315	01.08.98	Mkh-1-I-02-50	TI	X	X	X	-	X	-	-
316	01.08.98	Mkh-1-I-02-51	TI	X	X	X	-	-	7.40	1217
317	01.08.98	MKh-1-96-01 AD	SW	X	X	X	-	X	7.46	528
318	01.08.98	MKh-KR-I-1	IW	X	X	-	-	X	7.76	195
319	01.08.98	MKh-KR-I-2	IW	X	X	-	-	-	-	-
320	01.08.98	MKh-KR-I-3	IW	X	X	-	-	-	7.74	156
321	01.08.98	MKh-KR-I-4	IW	X	X	-	-	-	7.56	140
322	01.08.98	MKh-KR-I-5	IW	X	X	-	-	-	7.60	210
323	01.08.98	MKh-KR-I-6	IW	X	X	-	-	X	7.75	146
324	01.08.98	MKh-KR-I-7	IW	X	X	-	-	-	-	-
325	01.08.98	MKh-KR-I-8	IW	X	X	-	-	-	7.11	1015
326	01.08.98	MKh-KR-I-9	IW	X	X	-	-	-	7.59	134
327	01.08.98	MKh-KR-I-10	IW	X	X	-	-	-	7.45	344
328	01.08.98	MKh-KR-I-11	IW	X	X	-	-	X	7.39	191
329	01.08.98	MKh-KR-I-12	IW	X	X	-	-	-	7.53	193
330	01.08.98	MKh-KR-I-13	IW	X	X	-	-	-	7.70	226
331	01.08.98	MKh-KR-I-14	IW	X	X	-	-	-	7.99	370
332	01.08.98	MKh-KR-I-15	IW	X	X	-	-	-	8.05	200
333	01.08.98	MKh-KR-I-16	IW	X	X	-	-	X	7.82	214
334	01.08.98	MKh-KR-I-17	IW	X	X	-	-	-	7.72	345
335	01.08.98	MKh-KR-I-18	IW	X	X	-	-	-	7.48	238
336	01.08.98	MKh-KR-I-19	TI	X	X	-	-	-	7.56	454
337	01.08.98	MKh-KR-I-20	TI	X	X	-	-	-	7.52	395
338	01.08.98	MKh-KR-I-21	TI	X	X	-	-	X	-	-
339	01.08.98	MKh-KR-I-22	TI	X	X	-	-	-	7.74	390
340	01.08.98	MKh-KR-I-23	TI	X	X	-	-	-	7.48	523

Table A5-1: continuation

					Isotopes			Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
341	01.08.98	MKh-KR-I-24	TI	X	X	-	-	-	7.64	510
342	01.08.98	MKh-KR-I-25	TI	X	X	-	-	-	7.50	540
343	02.08.98	BYK 99/03 HM	RW	X	X	-	-	X	6.78	6.6
344	02.08.98	MKh-K8a-I-1	IW	X	X	-	-	-	8.02	192
345	02.08.98	MKh-K8a-I-2	IW	X	X	-	-	-	-	-
346	02.08.98	MKh-K8a-I-3	IW	X	X	-	-	-	7.32	329
347	03.08.98	BYK 98/04	GW	X	X	X	-	X	5.20	38
348	03.08.98	BYK 98/05	GW	X	X	X	-	X	5.27	35
349	03.08.98	BYK 96/02 HM	EW	X	X	-	-	-	5.92	12.6
350	03.08.98	MKh-4.6-I-1	IW	X	X	X	-	X	7.49	-
351	03.08.98	MKh-4.6-I-2	IW	X	X	X	-	-	7.70	142
352	03.08.98	MKh-4.6-I-3	IW	X	X	X	-	-	7.21	54
353	03.08.98	MKh-4.6-I-4	IW	X	X	X	-	-	7.72	160
354	03.08.98	MKh-4.6-I-5	IW	X	X	X	-	X	7.83	121
355	03.08.98	MKh-4.6-I-6	IW	X	X	X	-	-	7.44	96
356	03.08.98	MKh-4.6-I-7	IW	X	X	X	-	-	7.49	97
357	03.08.98	MKh-4.6-I-8	IW	X	X	X	-	-	7.19	46
358	03.08.98	MKh-4.6-I-9	IW	X	X	X	-	-	7.84	82
359	03.08.98	MKh-4.6-I-10	IW	X	X	X	-	X	7.09	41
360	03.08.98	MKh-4.6-I-10A	IW	X	X	-	-	X	7.06	62
361	03.08.98	MKh-4.6-I-10B	IW	X	X	-	-	X	-	-
362	03.08.98	MKh-4.6-I-11	IW	X	X	X	-	X	7.25	60
363	03.08.98	MKh-4.6-I-12	IW	X	X	X	-	-	-	-
364	03.08.98	MKh-4.6-I-13	IW	X	X	-	-	-	7.04	35
365	03.08.98	MKh-4.6-I-14	IW	X	X	X	-	-	-	-
366	03.08.98	MKh-4.6-I-15	IW	X	X	-	-	X	6.01	38
367	03.08.98	MKh-4.6-I-16	IW	X	X	-	-	X	-	40
368	03.08.98	MKh-4.6-I-17	IW	X	X	-	-	-	6.09	34
369	03.08.98	MKh-4.6-I-18	IW	X	X	-	-	X	6.28	62
370	03.08.98	MKh-4.6-I-19	IW	X	X	-	-	-	-	-
371	03.08.98	MKh-4.6-I-20	IW	X	X	-	-	-	-	60
372	03.08.98	MKh-4.6-I-21	IW	X	X	-	-	X	7.08	56
373	03.08.98	MKh-4.6-I-22	IW	X	X	-	-	-	-	42
374	03.08.98	MKh-4.6-I-23	IW	X	X	-	-	-	7.25	52
375	03.08.98	MKh-4.6-I-24	IW	X	X	-	-	-	-	36
376	03.08.98	MKh-4.6-I-25	IW	X	X	-	-	X	6.82	63
377	03.08.98	MKh-4.6-I-26	IW	X	X	X	-	-	-	77
378	03.08.98	MKh-4.6-I-27	IW	X	X	-	-	-	-	-
379	03.08.98	MKh-4.6-I-28	IW	X	X	-	-	-	-	67
380	03.08.98	MKh-4.6-I-29	IW	X	X	-	-	-	7.32	91
381	03.08.98	MKh-4.6-I-30	IW	X	X	-	-	-	-	38
382	03.08.98	MKh-4.6-I-31	IW	X	X	-	-	X	5.41	30
383	03.08.98	MKh-4.6-I-32	IW	X	X	-	-	-	-	42

Table A5-1: continuation

				Isotopes				Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
384	03.08.98	MKh-4.6-I-33	IW	X	X	-	-	-	6.46	31
385	03.08.98	MKh-4.6-I-34	IW	X	X	-	-	-	-	28
386	03.08.98	MKh-4.6-I-35	IW	X	X	-	-	X	7.33	43
387	03.08.98	MKh-4.6-I-36	IW	X	X	-	-	-	-	52
388	03.08.98	MKh-4.6-I-37	IW	X	X	-	-	-	6.95	53
389	03.08.98	MKh-4.6-I-38	IW	X	X	-	-	X	6.38	83
390	03.08.98	MKh-4.6-I-39	IW	X	X	-	-	-	6.92	84
391	03.08.98	MKh-4.6-I-40	IW	X	X	-	-	X	6.90	78
392	03.08.98	MKh-4.6-I-41	IW	X	X	-	-	-	-	-
393	03.08.98	MKh-4.6-I-42	IW	X	X	-	-	-	7.14	60
394	03.08.98	MKh-4.6-I-43	IW	X	X	-	-	-	7.39	98
395	03.08.98	MKh-4.6-I-44	IW	X	X	-	-	-	7.93	102
396	03.08.98	MKh-4.6-I-45	IW	X	X	-	-	X	7.37	57
397	03.08.98	MKh-4.6-I-46	IW	X	X	X	-	X	6.66	27
398	03.08.98	MKh-4.6-I-47	IW	X	X	-	-	X	7.51	47
399	03.08.98	MKh-4.6-I-48	IW	X	X	-	-	X	7.12	51
400	03.08.98	MKh-4.6-I-49	IW	X	X	-	-	-	5.92	128
401	03.08.98	MKh-4.6-I-50	TI	X	X	X	-	X	6.14	13
402	03.08.98	MKh-4.6-I-51	TI	X	X	X	-	-	-	-
403	03.08.98	MKh-4.6-I-52	TI	X	X	X	-	-	-	-
404	03.08.98	MKh-4.6-I-53	TI	X	X	X	-	-	5.41	54
405	03.08.98	MKh-4.6-I-54	TI	X	X	X	-	-	-	-
406	03.08.98	BYK 96/03 HM	SW	X	X	X	-	X	7.56	52
407	04.08.98	KB-2-I-1	TI	X	X	-	-	X	7.24	742
408	04.08.98	KB-6-I-1	TI	X	X	-	-	X	7.18	2340
409	04.08.98	KB-6-I-2	TI	X	X	-	-	X	7.14	1020
410	04.08.98	KB-6-I-4	TI	X	X	-	-	X	6.86	1920
411	04.08.98	KB-6-I-8	TI	X	X	-	-	X	6.83	3550
412	04.08.98	KB-6-I-11	TI	X	X	-	-	X	7.09	728
413	04.08.98	KB-7-I-1	TI	X	X	-	-	X	6.95	792
414	04.08.98	KB-7-I-4	TI	X	X	-	-	X	7.43	1573
415	04.08.98	KB-7-I-6	TI	X	X	-	-	X	6.90	832
416	04.08.98	KB-9-I-1	TI	X	X	-	-	X	7.23	483
417	04.08.98	KB-9-I-2	TI	X	X	-	-	X	6.95	1301
418	04.08.98	MKh-4.1-I-1	TI	X	X	-	-	X	7.34	1897
419	04.08.98	MKh-4.1-I-2	TI	X	X	-	-	X	7.22	3290
420	04.08.98	MKh-4.1-I-4	TI	X	X	-	-	X	7.30	5420
421	04.08.98	MKh-4.2-I-1	TI	X	X	-	-	X	7.37	2640
422	04.08.98	MKh-4.2-I-2	TI	X	X	-	-	X	7.51	2870
423	04.08.98	MKh-4.3-I-2	TI	X	X	-	-	X	6.11	793
424	04.08.98	NK-4-I-1	IW	X	X	-	-	-	-	-
425	04.08.98	NK-4-I-2	IW	X	X	-	-	-	-	-
426	04.08.98	NK-4-I-3	IW	X	X	-	-	-	-	-

Table A5-1: continuation

				Isotopes				Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
427	04.08.98	NK-4-I-4	IW	X	X	-	-	-	-	-
428	04.08.98	MKh-1.6-I-1	IW	X	X	X	-	-	7.31	71
429	04.08.98	MKh-1.6-I-2	IW	X	X	X	-	-	7.38	281
430	04.08.98	MKh-1.6-I-3	IW	X	X	X	-	-	-	-
431	04.08.98	MKh-1.6-I-4	IW	X	X	X	-	-	8.00	151
432	04.08.98	MKh-1.6-I-5	IW	X	X	X	-	-	-	-
433	04.08.98	MKh-1-3-I-1	IW	X	X	X	-	X	5.42	45
434	04.08.98	MKh-1-3-I-2	IW	X	X	X	-	X	-	-
435	04.08.98	MKh-1-3-I-3	IW	X	X	X	-	-	-	-
436	04.08.98	MKh-1-3-I-4	IW	X	X	X	-	-	-	-
437	04.08.98	MKh-1-3-I-5	IW	X	X	X	-	-	-	-
438	04.08.98	MKh-1-3-I-6	IW	X	X	X	-	X	-	-
439	04.08.98	MKh-1-3-I-7	IW	X	X	X	-	-	-	-
440	04.08.98	MKh-1-3-I-8	IW	X	X	X	-	-	-	-
441	04.08.98	MKh-1-3-I-9	IW	X	X	X	-	-	-	-
442	04.08.98	MKh-1-3-I-10	IW	X	X	X	-	X	-	-
443	04.08.98	MKh-a-1	IW	X	X	X	-	-	7.35	70
444	04.08.98	MKh-a-2	IW	X	X	X	-	-	7.53	210
445	04.08.98	MKh-96-I-10	SW	X	X	X	-	X	6.78	52
446	06.08.98	BYK 99/04 HM	RW	X	X	X	-	X	6.52	11.8
447	06.08.98	BYK 98/06 HM	GW	X	X	X	-	-	5.20	40
448	06.08.98	BYK 98/07 HM	GW	X	X	X	-	X	5.22	36
449	06.08.98	BYK-A2-I-1	IW	X	X	-	-	X	7.08	92
450	06.08.98	BYK-A2-I-2	IW	X	X	-	-	X	7.30	79
451	06.08.98	BYK-A2-I-3	IW	X	X	-	-	X	7.04	84
452	06.08.98	BYK-A2-I-4	IW	X	X	X	-	-	-	79
453	06.08.98	BYK-A2-I-5	IW	X	X	-	-	-	7.33	91
454	06.08.98	BYK-A2-I-6	IW	X	X	-	-	-	-	-
455	06.08.98	BYK-A2-I-7	IW	X	X	-	-	-	7.12	161
456	06.08.98	BYK-A2-I-8	IW	X	X	-	-	-	-	-
457	06.08.98	BYK-A2-I-9	IW	X	X	-	-	-	6.76	92
458	06.08.98	BYK-A2-I-10	IW	X	X	-	-	X	-	-
459	06.08.98	BYK-A2-I-11	IW	X	X	-	-	-	6.61	82
460	06.08.98	BYK-A2-I-12	IW	X	X	-	-	-	-	-
461	06.08.98	BYK-A2-I-13	IW	X	X	-	-	-	6.25	89
462	06.08.98	BYK-A2-I-14	IW	X	X	-	-	-	-	-
463	06.08.98	BYK-A2-I-15	IW	X	X	-	-	-	6.23	88
464	06.08.98	BYK-A2-I-16	IW	X	X	-	-	-	-	-
465	06.08.98	BYK-A2-I-17	IW	X	X	-	-	-	6.15	77
466	06.08.98	BYK-A2-I-18	IW	X	X	-	-	-	-	-
467	06.08.98	BYK-A2-I-19	IW	X	X	-	-	-	6.56	88
468	06.08.98	BYK-A2-I-20	IW	X	X	-	-	X	-	-
469	06.08.98	BYK-A2-I-21	IW	X	X	-	-	-	6.81	76

Table A5-1: continuation

				Isotopes				Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
470	06.08.98	BYK-A2-I-22	IW	X	X	-	-	-	-	-
471	06.08.98	BYK-A2-I-23	IW	X	X	-	-	-	6.79	86
472	06.08.98	BYK-A2-I-24	IW	X	X	-	-	-	-	-
473	06.08.98	BYK-A2-I-25	IW	X	X	-	-	-	7.56	110
474	06.08.98	BYK-A2-I-26	IW	X	X	-	-	-	-	-
475	06.08.98	BYK-A2-I-27	IW	X	X	-	-	-	7.45	130
476	06.08.98	BYK-A2-I-28	IW	X	X	-	-	-	-	-
477	06.08.98	BYK-A2-I-29	IW	X	X	-	-	-	7.10	109
478	06.08.98	BYK-A2-I-30	IW	X	X	-	-	X	-	-
479	06.08.98	BYK-A2-I-31	IW	X	X	-	-	-	6.75	90
480	06.08.98	BYK-A2-I-32	IW	X	X	-	-	-	-	-
481	06.08.98	BYK-A2-I-33	IW	X	X	-	-	-	6.96	122
482	06.08.98	BYK-A2-I-34	IW	X	X	-	-	-	-	-
483	06.08.98	BYK-A2-I-35	IW	X	X	-	-	-	7.66	233
484	06.08.98	BYK-A2-I-36	IW	X	X	-	-	-	-	-
485	06.08.98	BYK-A2-I-37	IW	X	X	-	-	-	7.47	131
486	06.08.98	BYK-A2-I-38	IW	X	X	X	-	-	-	-
487	06.08.98	BYK-A2-I-39	IW	X	X	-	-	-	7.23	107
488	06.08.98	BYK-A2-I-40	IW	X	X	-	-	X	-	-
489	06.08.98	BYK-A2-I-41	IW	X	X	-	-	-	7.63	201
490	06.08.98	BYK-A2-I-42	IW	X	X	-	-	-	-	-
491	06.08.98	BYK-A2-I-43	IW	X	X	-	-	-	6.93	120
492	06.08.98	BYK-A2-I-44	IW	X	X	-	-	-	-	-
493	06.08.98	BYK-A2-I-45	IW	X	X	-	-	-	6.79	91
494	06.08.98	BYK-A2-I-46	IW	X	X	-	-	-	-	-
495	06.08.98	BYK-A2-I-47	IW	X	X	-	-	-	6.71	100
496	06.08.98	BYK-A2-I-48	IW	X	X	-	-	-	-	-
497	06.08.98	BYK-A2-I-49	IW	X	X	X	-	-	6.69	63
498	06.08.98	BYK-A2-I-50	IW	X	X	-	-	X	-	-
499	06.08.98	BYK-A2-I-51	IW	X	X	-	-	-	7.21	59
500	06.08.98	BYK-A2-I-52	IW	X	X	-	-	-	-	-
501	06.08.98	BYK-A2-I-53	IW	X	X	-	-	-	7.37	68
502	06.08.98	BYK-A2-I-54	IW	X	X	-	-	-	-	-
503	06.08.98	BYK-A2-I-55	IW	X	X	-	-	-	6.98	63
504	06.08.98	BYK-A2-I-56	IW	X	X	X	-	-	-	-
505	06.08.98	BYK-A2-I-57	IW	X	X	-	-	-	6.74	52
506	06.08.98	BYK-A2-I-58	IW	X	X	-	-	X	6.96	49
507	06.08.98	BYK-A2-I-59	IW	X	X	X	-	X	5.57	53
508	06.08.98	BYK-A2-I-60	IW	X	X	-	-	X	-	-
509	06.08.98	BYK-A2-I-61	IW	X	X	-	-	X	-	-
510	06.08.98	BYK-A2-I-62	IW	X	X	-	-	X	-	-
511	06.08.98	BYK-A2-I-63	IW	X	X	X	-	-	7.13	57
512	06.08.98	BYK-A2-I-64	IW	X	X	X	-	-	-	-

Table A5-1: continuation

				Isotopes				Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
513	06.08.98	BYK-A2-I-65	IW	X	X	-	-	-	7.18	42
514	06.08.98	BYK-A2-I-66	IW	X	X	X	-	-	-	-
515	06.08.98	BYK-A2-I-67	IW	X	X	-	-	-	-	-
516	06.08.98	BYK-A2-I-68	IW	X	X	-	-	-	-	-
517	06.08.98	BYK-A2-I-69	IW	X	X	X	-	-	6.78	34
518	06.08.98	BYK-A2-I-70	IW	X	X	X	-	X	-	-
519	06.08.98	BYK-A2-I-71	IW	X	X	X	-	-	7.07	41
520	06.08.98	BYK-A2-I-72	IW	X	X	X	-	-	-	-
521	06.08.98	BYK-A2-I-73	IW	X	X	X	-	-	6.48	35
522	06.08.98	BYK-A2-I-74	IW	X	X	X	-	-	-	-
523	06.08.98	BYK-A2-I-75	IW	X	X	-	-	-	6.99	90
524	06.08.98	BYK-A2-I-76	IW	X	X	-	-	-	-	-
525	06.08.98	BYK-A2-I-77	IW	X	X	X	-	-	6.48	47
526	06.08.98	BYK-A2-I-78	IW	X	X	-	-	-	-	-
527	06.08.98	BYK-A2-I-79	IW	X	X	-	-	-	6.81	57
528	06.08.98	BYK-A2-I-80	IW	X	X	X	-	X	-	-
529	06.08.98	BYK-A2-I-81	IW	X	X	-	-	-	6.81	45
530	06.08.98	BYK-A2-I-82	IW	X	X	X	-	-	-	-
531	06.08.98	BYK-A2-I-83	IW	X	X	-	-	-	6.93	43
532	06.08.98	BYK-A2-I-84	IW	X	X	-	-	-	-	-
533	06.08.98	BYK-A2-I-85	IW	X	X	X	-	-	6.64	46
534	06.08.98	BYK-A2-I-86	IW	X	X	-	-	-	-	-
535	06.08.98	BYK-A2-I-87	IW	X	X	X	-	-	7.08	74
536	06.08.98	BYK-A2-I-88	IW	X	X	-	-	-	-	-
537	06.08.98	BYK-A2-I-89	IW	X	X	-	-	-	6.94	62
538	06.08.98	BYK-A2-I-89A	IW	X	X	-	-	-	-	-
539	06.08.98	BYK-A2-I-90	IW	X	X	X	-	X	-	-
540	06.08.98	BYK-A2-I-91	IW	X	X	-	-	-	6.91	49
541	06.08.98	BYK-A2-I-92	IW	X	X	-	-	-	-	-
542	06.08.98	BYK-A2-I-93	IW	X	X	-	-	-	7.52	52
543	06.08.98	BYK-A2-I-94	IW	X	X	-	-	-	-	-
544	06.08.98	BYK-A2-I-95	IW	X	X	-	-	-	-	-
545	06.08.98	BYK-A2-I-96	IW	X	X	-	-	-	-	-
546	06.08.98	BYK-A2-I-97	IW	X	X	-	-	-	7.24	51
547	06.08.98	BYK-A2-I-98	IW	X	X	-	-	-	-	-
548	06.08.98	BYK-A2-I-99	IW	X	X	-	-	X	6.77	32
549	06.08.98	BYK-A2-I-100	IW	X	X	X	-	-	-	-
550	06.08.98	BYK-A2-I-101	IW	X	X	X	-	-	6.22	117
551	06.08.98	BYK-A2-I-102	IW	X	X	X	-	-	-	-
552	06.08.98	BYK-A2-I-103	IW	X	X	-	-	-	6.07	93
553	06.08.98	BYK-A2-I-104	IW	X	X	-	-	-	-	-
554	06.08.98	BYK-A2-I-105	IW	X	X	-	-	-	6.40	102
555	06.08.98	BYK-A2-I-106	IW	X	X	-	-	-	-	-

Table A5-1: continuation

				Isotopes				Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
556	06.08.98	BYK-A2-I-107	IW	X	X	-	-	-	6.57	129
557	06.08.98	BYK-A2-I-108	IW	X	X	-	-	-	-	-
558	06.08.98	BYK-A2-I-109	IW	X	X	X	-	-	7.00	181
559	06.08.98	BYK-A2-I-110	IW	X	X	-	-	X	-	-
560	06.08.98	BYK-A2-I-111	IW	X	X	X	-	-	-	-
561	06.08.98	BYK-A2-I-112	IW	X	X	-	-	-	-	-
562	06.08.98	BYK-A2-I-113	IW	X	X	-	-	-	-	-
563	07.08.98	BYK-99/05 AD	RW	X	X	X	-	X	6.09	11.2
564	08.08.98	BYK-96-I-11	SW	X	X	X	-	-	6.93	105
565	08.08.98	MKh-1.1-I-1	TI	X	X	-	-	X	-	-
566	08.08.98	MKh-1.1-I-2	TI	X	X	-	-	X	-	-
567	08.08.98	MKh-1.2-I-1	TI	X	X	-	-	X	-	-
568	08.08.98	MKh-6.1-I-1	TI	X	X	-	-	X	-	-
569	08.08.98	MKh-6.1-I-2	TI	X	X	-	-	X	-	-
570	08.08.98	MKh-6.1-I-3	TI	X	X	-	-	-	-	-
571	08.08.98	MKh-6.1-I-6	TI	X	X	-	-	X	-	-
572	09.08.98	BYK-99/06 HM	RW	X	X	X	-	X	6.13	7.6
573	09.08.98	BYK 98/08 HM	GW	X	X	X	-	X	5.15	43.1
574	09.08.98	BYK 98/09 HM	GW	X	X	X	-	X	5.23	30.1
575	09.08.98	MKh-1.6-96-I-1	SW	X	X	X	-	X	7.10	97
576	09.08.98	BYK-96/12 HM	SW	X	X	X	-	X	7.56	68
577	09.08.98	BYK-96/13 HM	SW	X	X	X	-	X	7.04	85
578	09.08.98	BYK-96/14 HM	SW	X	X	X	-	X	7.58	1045
579	10.08.98	BYK-99/07 HM	RW	X	X	X	-	X	6.10	21.2
580	09.08.98	BYK-96/15 AD	SW	X	X	X	-	X	7.56	74
581	09.08.98	BYK-96/16 AD	SW	X	X	X	-	X	-	25
582	12.08.98	BYK-A1-I-1	IW	X	X	-	-	-	8.09	203
583	12.08.98	BYK-A1-I-2	IW	X	X	-	-	-	-	
584	12.08.98	BYK-A1-I-3	IW	X	X	-	-	-	-	121
585	12.08.98	BYK-A1-I-4	IW	X	X	-	-	-	-	-
586	12.08.98	BYK-A1-I-5	IW	X	X	-	-	-	7.69	262
587	12.08.98	BYK-A1-I-6	IW	X	X	-	-	-	-	-
588	12.08.98	BYK-A1-I-7	IW	X	X	-	-	-	7.86	148
589	12.08.98	BYK-A1-I-8	IW	X	X	-	-	-	-	-
590	12.08.98	BYK-A1-I-9	IW	X	X	-	-	-	7.28	113
591	12.08.98	BYK-A1-I-10	IW	X	X	-	-	-	-	-
592	12.08.98	BYK-A1-I-11	IW	X	X	-	-	-	7.66	68
593	12.08.98	BYK-A1-I-12	IW	X	X	-	-	-	-	140
594	12.08.98	BYK 98/10 HM	GW	X	X	-	-	-	-	-
595	12.08.98	BYK 98/11 HM	GW	X	X	X	-	X	5.53	30
596	12.08.98	BYK-A2-Be-1	IW	X	X	-	X	-	-	-
597	12.08.98	BYK-A2-Be-2	IW	X	X	-	X	-	-	-
598	12.08.98	BYK-A2-Be-3	IW	X	X	-	X	-	-	-

Table A5-1: continuation

Nr.	date	sample	type	Isotopes 18 O	2 H	3 H	10 Be	Chemistry anion /cation	pH	LF
599	12.08.98	BYK-A2-Be-4	IW	X	X	-	X	-	-	-
600	12.08.98	BYK-A2-Be-5	IW	X	X	-	X	-	-	-
601	12.08.98	BYK-A2-Be-6	IW	X	X	-	X	-	-	-
602	12.08.98	BYK-A2-Be-7	IW	X	X	-	X	-	-	-
603	12.08.98	BYK-A2-Be-8	IW	X	X	-	X	-	-	-
604	12.08.98	BYK-A2-Be-9	IW	X	X	-	X	-	-	-
605	12.08.98	BYK-A2-Be-10	IW	X	X	-	X	-	-	-
606	12.08.98	BYK-A2-Be-11	IW	X	X	-	X	-	-	-
607	12.08.98	BYK-A2-Be-12	IW	X	X	-	X	-	-	-
608	12.08.98	BYK-A2-Be-13	IW	X	X	-	X	-	-	-
609	12.08.98	MKh-6.1-I-1	TI	X	X	-	-	X	5.85	85
610	12.08.98	MKh-4.12-I-2	TI	X	X	-	-	X	6.41	497
611	12.08.98	MKh-4.12-I-3	TI	X	X	-	-	X	6.39	414
612	12.08.98	MKh-4.12-I-4	TI	X	X	-	-	-	7.14	152
613	12.08.98	BYK-A1-I-13	IW	-	-	-	-	-	-	-
614	13.08.98	BYK-99/08 HM	RW	X	X	X	-	X	6.18	5
615	12.08.98	BYK-BH-1-1	AL	X	X	X	-	X	7.20	46
616	14.08.98	BYK-96/17	SW	X	X	X	-	X	6.66	67
617	14.08.98	BYK-96/18	SW	X	X	X	-	X	6.82	50
618	14.08.98	BYK-96/19	SW	X	X	X	-	X	6.99	50
619	14.08.98	BYK-96/20	SW	X	X	X	-	X	7.00	47
620	14.08.98	BYK-96/21	SW	X	X	X	-	X	7.03	151
621	14.08.98	BYK-96/22	SW	X	X	X	-	X	7.17	51
622	14.08.98	BYK-97/05 VK	SP	X	X	X	-	X	6.15	11.5
623	14.08.98	BYK-BH-2-1	AL	X	X	X	-	-	-	-
624	14.08.98	BYK-BH-2-2	AL	X	X	X	-	-	6.79	96
625	14.08.98	BYK-99/09 HM	RW	X	X	X	-	X	6.03	21.8
626	15.08.98	BYK-99/10 HM	RW	X	X	X	-	X	6.07	25
627	15.08.98	BYK-BH-3-1	AL	X	X	X	-	X	-	-
628	15.08.98	BYK-BH-3-2	PI	X	X	X	-	X	7.19	67
629	15.08.98	BYK-BH-3-3	PI	X	X	X	-	X	7.59	158
630	15.08.98	BYK-BH-3-4	PI	X	X	X	-	-	-	-
631	15.08.98	BYK-BH-3-5	PI	X	X	X	-	-	-	-
632	15.08.98	BYK-A2-I-114	IW	X	X	-	-	-	-	-
633	15.08.98	BYK-A2-I-115	IW	X	X	-	-	-	-	-
634	15.08.98	BYK-A2-I-116	IW	X	X	-	-	-	-	-
635	15.08.98	BYK-A2-I-117	IW	X	X	-	-	-	-	-
636	15.08.98	BYK-A2-I-118	IW	X	X	-	-	-	-	-
637	15.08.98	BYK-A2-I-119	IW	X	X	-	-	-	-	-
638	15.08.98	BYK-A2-I-120	IW	X	X	-	-	-	-	-
639	15.08.98	BYK-A2-I-121	IW	X	X	-	-	-	-	-
640	15.08.98	BYK-A2-I-122	IW	X	X	-	-	-	-	-
641	15.08.98	BYK-A2-I-123	IW	X	X	-	-	-	-	-

Table A5-1: continuation

						Isotopes		Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
642	15.08.98	BYK-A2-I-124	IW	X	X	-	-	-	-	-
643	15.08.98	BYK-A2-I-125	IW	X	X	-	-	-	-	-
644	15.08.98	BYK-A2-I-126	IW	X	X	-	-	-	-	-
645	15.08.98	BYK-A2-I-127	IW	X	X	-	-	-	-	-
646	15.08.98	BYK-A2-I-128	IW	X	X	-	-	-	-	-
647	15.08.98	BYK-A2-I-129	IW	X	X	-	-	-	-	-
648	15.08.98	BYK-A2-I-130	IW	X	X	-	-	-	-	-
649	15.08.98	BYK-A2-I-131	IW	X	X	-	-	-	-	-
650	15.08.98	BYK-A2-I-132	IW	X	X	-	-	-	-	-
651	15.08.98	BYK-A2-I-133	IW	X	X	-	-	-	-	-
652	15.08.98	BYK-A2-I-134	IW	X	X	-	-	-	-	-
653	15.08.98	BYK-96/24 CS	SW	X	X	X	-	X	6.83	56
654	15.08.98	BYK-96/25 CS	SW	X	X	X	-	X	6.87	35
655	15.08.98	BYK-96/23 HM	SW	X	X	X	-	X	6.08	29
656	16.08.98	BYK-98/12 HM	GW	X	X	X	-	-	-	-
657	16.08.98	BYK-98/13 HM	GW	X	X	X	-	X	5.43	40.7
658	16.08.98	BYK-BH-4-1	AL	X	X	X	-	-	7.24	981
659	16.08.98	BYK-BH-4-2	AL	X	X	-	-	-	7.32	717
660	16.08.98	BYK-BH-5-1	AL	X	X	X	-	-	6.48	166
661	16.08.98	BYK-BH-5-2	AL	X	X	X	-	-	6.34	127
662	16.08.98	BYK-BH-6-1	AL	X	X	X	-	-	6.42	57
663	16.08.98	BYK-BH-6-2	AL	X	X	X	-	-	6.58	147
664	16.08.98	BYK-BH-6-3	AL	X	X	X	-	-	-	-
665	16.08.98	MKh-4.13-I-1	IW	X	X	-	-	-	7.19	399
666	16.08.98	MKh-4.13-I-2	IW	X	X	-	-	-	-	-
667	16.08.98	MKh-4.13-I-3	IW	X	X	X	-	-	-	-
668	16.08.98	MKh-4.13-I-4	IW	X	X	X	-	-	-	-
669	16.08.98	MKh-4.13-I-5	IW	X	X	X	-	X	7.19	33
670	16.08.98	MKh-4.13-I-6	IW	X	X	X	-	-	-	-
671	16.08.98	MKh-4.13-I-7	IW	X	X	-	-	-	-	-
672	16.08.98	MKh-4.13-I-8	IW	X	X	X	-	-	-	-
673	16.08.98	MKh-4.13-I-9	IW	X	X	X	-	-	-	-
674	16.08.98	MKh-4.13-I-10	IW	X	X	X	-	X	7.54	123
675	16.08.98	MKh-4.13-I-11	IW	X	X	-	-	-	8.04	179
676	16.08.98	MKh-4.13-I-12	IW	X	X	-	-	-	-	-
677	16.08.98	MKh-4.13-I-13	IW	X	X	-	-	-	7.44	59
678	16.08.98	MKh-4.13-I-14	IW	X	X	-	-	-	-	45
679	16.08.98	MKh-4.13-I-15	IW	X	X	-	-	X	6.81	59
680	16.08.98	MKh-4.13-I-16	IW	X	X	-	-	-	7.13	55
681	16.08.98	MKh-4.13-I-18	IW	X	X	-	-	-	-	-
682	16.08.98	MKh-4.13-I-19	IW	X	X	-	-	-	8.00	225
683	16.08.98	MKh-4.13-I-20	IW	X	X	-	-	X	-	-
684	16.08.98	MKh-4.13-I-21	IW	X	X	-	-	-	9.46	99

Table A5-1: continuation

Nr.	date	sample	type	Isotopes 18 O	2 H	3 H	10 Be	Chemistry anion /cation	pH	LF
685	16.08.98	MKh-4.13-I-22	IW	X	X	-	-	-	-	-
686	16.08.98	MKh-4.13-I-23	IW	X	X	-	-	-	8.48	184
687	16.08.98	MKh-4.13-I-24	IW	X	X	-	-	-	-	-
688	16.08.98	MKh-4.13-I-25	IW	X	X	-	-	X	8.17	150
689	16.08.98	MKh-4.13-I-26	IW	X	X	-	-	-	-	-
690	16.08.98	MKh-4.13-I-27	IW	X	X	-	-	-	8.36	162
691	16.08.98	MKh-4.13-I-28	IW	X	X	-	-	-	-	-
692	16.08.98	MKh-4.13-I-29	IW	X	X	-	-	-	7.89	161
693	16.08.98	MKh-4.13-I-30	IW	X	X	-	-	X	-	-
694	16.08.98	MKh-4.13-I-31	IW	X	X	-	-	-	8.03	169
695	16.08.98	MKh-4.13-I-32	IW	X	X	-	-	-	-	-
696	16.08.98	MKh-4.13-I-33	IW	X	X	-	-	-	8.04	154
697	16.08.98	MKh-4.13-I-34	IW	X	X	-	-	-	-	-
698	16.08.98	MKh-4.13-I-35	IW	X	X	-	-	X	7.87	148
699	16.08.98	MKh-4.13-I-36	IW	X	X	-	-	-	-	-
700	16.08.98	MKh-4.13-I-37	IW	X	X	-	-	-	8.17	170
701	16.08.98	MKh-4.13-I-38	IW	X	X	-	-	-	-	-
702	16.08.98	MKh-4.13-I-39	IW	X	X	-	-	-	8.33	130
703	16.08.98	MKh-4.13-I-40	IW	X	X	-	-	X	-	-
704	16.08.98	MKh-4.13-I-41	IW	X	X	-	-	-	8.40	96
705	16.08.98	MKh-4.13-I-42	IW	X	X	-	-	-	-	-
706	16.08.98	MKh-4.13-I-43	IW	X	X	-	-	-	8.33	91
707	16.08.98	MKh-4.13-I-44	IW	X	X	-	-	-	-	-
708	16.08.98	MKh-4.13-I-45	IW	X	X	-	-	X	8.15	180
709	16.08.98	MKh-4.13-I-46	IW	X	X	-	-	-	8.04	96
710	16.08.98	MKh-4.13-I-47	IW	X	X	-	-	-	-	-
711	16.08.98	MKh-4.13-I-48	IW	X	X	-	-	-	-	-
712	16.08.98	MKh-4.13-I-49	IW	X	X	-	-	-	7.58	68
713	16.08.98	MKh-4.13-I-50	IW	X	X	-	-	X	-	-
714	16.08.98	MKh-4.13-I-51	IW	X	X	-	-	-	8.22	108
715	16.08.98	MKh-4.13-I-51A	IW	X	X	-	-	-	8.17	121
716	16.08.98	MKh-4.13-I-51B	IW	X	X	-	-	-	8.08	111
717	16.08.98	MKh-4.13-I-52	IW	X	X	X	-	-	-	-
718	16.08.98	MKh-4.13-I-53	IW	X	X	-	-	-	6.84	42
719	16.08.98	MKh-4.13-I-54	IW	X	X	-	-	-	7.90	65
720	16.08.98	MKh-3-S-2	TI	X	X	-	-	X	7.64	1457
721	16.08.98	MKh-3-S-3	TI	X	X	-	-	X	-	-
722	16.08.98	MKh-3-S-4	TI	X	X	-	-	X	7.25	845
723	16.08.98	MKh-3-S-5	TI	X	X	-	-	X	-	-
724	17.08.98	BYK-99/11 HM	RW	X	X	-	-	X	4.32	29.6
725	18.08.98	MKh-3-Be-1	IW	X	X	-	X	-	-	-
726	18.08.98	MKh-3-Be-2	IW	X	X	-	X	-	-	-
727	18.08.98	MKh-3-Be-3	IW	X	X	-	X	-	-	-

Table A5-1: continuation

				Isotopes				Chemistry		
Nr.	date	sample	type	18 O	2 H	3 H	10 Be	anion /cation	pH	LF
728	18.08.98	MKh-3-Be-4	IW	X	X	-	X	-	-	-
729	18.08.98	MKh-3-Be-5	IW	X	X	-	X	-	-	-
730	18.08.98	MKh-3-Be-6	IW	X	X	-	X	-	-	-
731	18.08.98	MKh-3-Be-7	IW	X	X	-	X	-	-	-
732	18.08.98	MKh-3-Be-8	IW	X	X	-	X	-	-	-
733	18.08.98	MKh-3-Be-9	IW	X	X	-	X	-	-	-
734	18.08.98	MKh-3-Be-10	IW	X	X	-	X	-	-	-
735	18.08.98	MKh-3-Be-11	IW	X	X	-	X	-	-	-
736	18.08.98	MKh-3-Be-12	IW	X	X	-	X	-	-	-
737	18.08.98	MKh-3-Be-13	IW	X	X	-	X	-	-	-
738	18.08.98	MKh-3-Be-14	IW	X	X	-	X	-	-	-
739	18.08.98	MKh-3-Be-15	IW	X	X	-	X	-	-	-
740	19.08.98	BYK-98/14 HM	GW	X	X	X	-	-	-	-
741	19.08.98	BYK-98/15 HM	GW	X	X	X	-	-	-	-
742	19.08.98	BYK-96/26 HM	SW	X	X	X	-	-	-	-
743	19.08.98	BYK-BH-7-1	AL	X	X	-	-	-	-	-
744	19.08.98	BYK-BH-8-1	AL	X	X	X	-	-	-	-
745	19.08.98	BYK-BH-8-2	AL	X	X	X	-	-	-	-
746	19.08.98	BYK-BH-9-1	AL	X	X	-	-	-	-	-
747	19.08.98	BYK-BH-9-2	AL	X	X	-	-	-	-	-
748	19.08.98	BYK-BH-9-3	AL	X	X	-	-	-	-	-
749	19.08.98	BYK-BH-10-1	AL	X	X	X	-	-	-	-
750	19.08.98	BYK-BH-10-2	AL	X	X	X	-	-	-	-
751	19.08.98	BYK-BH-10-3	AL	X	X	X	-	-	-	-

Abbreviations : SP = snow patch; RW = rain water; IW = ice wedge ice; SW = surface water; GW = ground water; PI = Pingo ice; EW = evaporation water; TI = texture ice; AL = active layer ice

Table A5-2: List and description of sediment samples collected on Bykovsky Peninsula.

Site: Baydsherakh „Kuno“ , seaside Hight: 7 m; width: 4-6 m
Sampling date: 28-29.7.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-1,5	Uniform sequence, clayish silt, dark graybrown, grass roots	Banded, ice layers (bands) 4-5 cm, interbeds 20-25 cm with lens-like structure, lenses 1-10 mm, hexogonal aggregates between the lenses						
0 -0,15	Silt		MKh-K1-1			**8,8**		Segregated ice for isotope analysis
0,15-0,30				16	155			
0,45-0,53				210	144			
1,30-1,50	Silt		MKh-K1-4					Segregated ice for isotope analysis
1,5-1,8	Peaty root horizon	Banded; low ice content,						**OSL-sample BYK 6**
1,5-1,72	Silt between clods of peaty silt		MKh-K1-6					Without horizonal boundaries; Segregated ice sample for isotope analysis
1,6-1,8	Peat inclusion		MKh-K1-5					**Sample for U/Th-dating;** Segregated ice for isotope analysis
1,6-2,1	Uniform sequence, clayish silt, dark gray-brown, grass roots	Banded, ice bands 2-3 cm, interbeds with lens-like structure, ice lenses 10 mm high and 5- 10 mm width				**10,8**		
1,75-1,85	Silt		MKh-K1-3					Segregated ice for isotope analysis
2,0				181	101			
2,1-2,2	peaty root horizon	low ice content	MKh-K1-2					
2.2-2,4	Uniform clayish silty sequence	Lower ice content, one ice band of 4 cm thickness						
2,4-2,5	Root horizon							
2,5-2,7	Uniform sequence, clayish silt, separate peat inclusions	Micro-lens-type structure (0.2 x 5 cm)						
2,7-4,0	Series of peaty soil horizons, many isolated peat inclusions							

Table A5-2: continuation

Site: Baydsherakh „Kuno“ , land side Hight: 7 m; width:. 4-6 m
Sampling date: 28-29.7.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
2 - 4	Alternation of layers with low and high ice contents (30 layers = 15 cycles), fine-sandy to clayish silt, without grass roots but plant fossils in ice layers	Banded, ice bands 5-10 cm, interbeds 10-15 cm with lens-like structure						
1,6 -1,65	Peaty root horizon		MKh K1-7					Correspond to the horizon 1,5-1,6 m of the seaside
1,8-2,0	Cryoturbated soil horizon, brown to reddish-brown			397	94	**10,8**		
2,25-2,4			MKh-K1-8					
2,7-2,8			MKh-K1-9					Segregated ice for isotope analysis
3,35-3,45			MKh-K1-10					Segregated ice for isotope analysis
3,6-3,75	Ice band			10	159			
3,7-3,75	Silty interlayer			281	121			
3,8-3,9			MKh-K1-11					Segregated ice for isotope analysis
4 - 5,2	Sequence of cryoturbated soil horizons							
4,0-4,5	Cryoturbated soil horizon; dark-brownish peat inclusions in gray brownish silt, fossil bones, shrub remains	Layered, layers (bands) up to 5 mm thick and 1 m long, distance 5-10 cm, weakly inclined orientation; interbeds with massive to micro-lens-like structure				**12,8**		Marker K1
3,9	Little bones of caribou							Bone samples
4,1-4,25	Shrub remains		MKh-K1-12-^{14}C					Sample for radiocarbon dating
4,2-4,3			MKh-K1-13					
4,3-4,4			MKh-K1-14					
4.4-4,5			MKh-K1-15	120	68			
4,5-4,6	With wood remains		MKh K1-16-^{14}C			**13,5**		Marker K2
4,6-4,7			MKh-K1-17					
4,7-4,8			MKh-K1-18					
5,0-5,1				5	159			
5,1-5,2			MKh-K1-19					
ca. 5,5	Soil horizon with peat inclusions					**14,3**		Marker K 3

Table A5-2: continuation

Site: Baydzherakh KB 1 Hight: 2 m
Sampling date: 01.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Cabonate content	Remarks
0-0,4 Horizont 1	Uniform sequence, clayish silt, grayish- brown, grass roots	Banded, alternation of coarse lens-like (lenses Ø 5 cm) and reticulated lens-like structures, ice schliere 2-3 mm	MKh-KB1-1	B 3	168	12,4-12,8	xx	
0,4-0,8 Horizon 2	Clayish silt, grayish-brown with reddish cryoturbatic structures, peat and shrub remains	Alternation of coarse lens-like and reticulated lens-like structures, ice lenses 2-3 mm thick	MKh-KB1-2-^{14}C	181	102	**12,8**-13,2	x	Marker 1.KB1
0,8-1,1 Horizon 3	Uniform sequence, clayish silt, grayish- brown, grass roots	Banded, alternation of bands of dense arranged ice lenses and layers (10-15 cm) with fine to medium reticulated lens-like structure	MKh--KB1-3	13	162	13,2-13,5	xx	
1,1-1,6 Horizon 4	Clayish silt, grayish-brown, with a lot of woody plant remains (dwarf shrubs mineral content is higher in the upper part of the horizon	Banded, alternation of bands of densly arranged ice lenses (20 cm long, 2-3 cm thick; distances 5 cm) and layers with fine reticulated lens-like structure	MKh-KB1-4-^{14}C	209	67	**13,5**-14,0	x	Marker 2. KB1

Site: Baydzherakh KB 2 Hight: ; width: 2 m
Sampling date: 30.07.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.	Carbonate content	Remarks
0,0-0,35	Soil horizon					**12,7**		Marker 1. KB 2
0,35-1,1	Clayish silt, grayish-brown, grass roots	Banded, subhorizontal structure	MKh-KB2-1	8	180		xx	Segregated ice for isotope analysis
1,1-1,4	Cryoturbated soil horizon with peat inclusions	Layered lens-like structure						
1,4-1,8	Cryoturbated soil horizon with peat clodes and shrub		MKh-KB2-2-^{14}C	164	95	**14,8**	-	Marker 2. KB 2
	remains		MKh-KB2-3-^{14}C	23	89		x	Separate sample for dating

Table A5-2: continuation

Site: Baydzherakh KB 3 Hight: 2m ; width: 2 m
Sampling date: 01.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.	Carbonate content	Remarks
< 0-0,2	Silt							
0,2-0,5	Soil horizon					13,5		Correspond to the marker 2KB1
0,5-0,9	Silt, gray, ice-rich							
0,9-1,15	Soil horizon							
1,15-1,35	Silt, gray, ice-rich							
1,35-1,5	Soil horizon							
1,5-1,6	Silt, gray, with peat inclusions	Irregularly reticulated lens-like structure, with subvertical ice inclined ice lenses (2-4 cm) in peat inclusions	MKh-KB3-3	17	115		xx	
1,6-2,0	Soil horizon; silt, gray, with peat inclusions;	Banded, ice bands to 0,5 m thick, distances 4-5 max. 10 cm, reticulated lens-like structure, lenses 1-3 cm, subverticale lenses (1-3 cm), lenses divide the horizon in several blocks	MKh-KB3-1 (peat) MKh-KB3-2 (silt)	115 4	97 98	15,0	- xx	Marker KB 3

Site: Baydzherakh KB 4 Hight: 4 m, width: 2 m
Sampling date: 01.08.

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-0,8	Silt	ice-rich *	MKh-KB4-1			14		
0,8-1,2 0,9-1,0 1.0-1,2	Soil horizon with wood remains		 MKh-KB4-2 MKh-KB4-8			**14,9**		Marker 1KB4
1,2-2,3	Silt	ice-rich *	MKh-KB4-3			15		
2,3-2,6 2,4-2,55 2,45-2,6	Soil horizon with gastropodes		 MKh-KB4-Gastr. MKh-KB4-4	 3	 129	**16,0**	 xx	 Marker 2KB4
2,6-3,7 3,3-3,45	Silt	ice-rich *	 MKh-KB4-5	 2	 181	17	 xx	
3,7-4,2 3,9-4,2	Soil horizon, silt with wood and peat inclusions		MKh-KB4-7 MKh-KB4-6	20	110	**17,3**	x	Marker 3KB4

Table A5-2: continuation

Site: Baydzherakh KB 5 Hight: 2 mwidth: 2
Sampling date: 30.07. 98

Hight at the profile [m]	Sediment description	Cryostructure	sample (sediment)	box-Nr. (ice)	ice content (%)	Altitude [m NN]	Carbonate content	Remarks
	soil horizon, silt		MKh-KB5-14C-1 MKh-KB5-14C-2			**17,2**		Marker 3KB5

Site: Baydzherakh KB 6 Hight: 8 m ; width: 8 m
Sampling date: 02.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-1	Silt	Banded						
1-1,2 Ho 1	Slowly developed soil horizon, mottled, low content of peaty material		MKh-KB6-1	397	94	**17,0**	xx	Marker 1KB6; Segregated ice for isotope analysis
1,2-2,3 Ho 2	Silt, with small amounts of roots	Banded ice lenses 4-6 cm thick, distances 10-15 cm max. 25 cm, big lenses (1-3 cm thick, interbeds reticulated lens-like	MKh-KB6-2	B1	99		xx	Segregated ice sample for isotope analysis
2,3-2,55 Ho 3	Soil horizon, silt, strongly rooted with peat inclusions	Interbeds fine reticulated lens-like, fine banded, with subvertical structures	MKh-KB6-3 (peat) MKh-KB6-4 (silt)	309	99	18,5	x	Marker 2KB6 Segregated ice for isotope analysis
2,55-3,0 Ho 4	Silt (like Ho 2)		MKh-KB6-5	1	96		xx	
3,0-3,4 Ho 5	Soil horizon, strongly rooted with peat inclusions (like Ho 3)		MKh-KB6-6 (peaty soil) MKh-KB6-7 (peat inclusion) MKh-KB6-8 (mineral soil)	111	139	18,8	x	Marker 3KB6 **Sample for U/Th-dating** Segregated ice for isotope analysis
3,4-3,8 Ho 6	Silt (like Ho 2)			21	156	19,2	x	
3,8-4,2 Ho 7	Cryoturbated soil horizon, silt, strong rooted, peaty soil, moss material dominated		MKh-KB6-9 MKh-KB6-10	354	111	**19,8**	x	Marker 4KB6
> 4,2	Silt, gray	ice rich *	MKh-KB6-11					Segregated ice for isotope analysis

Table A5-2: continuation

Site: Baydzherakh KB7 Hight: 3 m ; width: 2 m
Sampling date: 01.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-1,2 Ho 1	Silt, gray	Banded, ice bands 5-10 cm thick and massive, interbeds coarse reticulated lens-like, ~ 10 cm	MKh-KB7-1			19,5		Segregated ice sample for isotope analysis
1,2-1,7 Ho 2	Cryoturbated soil horizon, with irregularly distributed peat inclusions (10-20 cm), without woody fossil material	Fine- reticulated lens-like interbeds	MKh-KB7-2 (interbeds) MKh-KB7-3 (peat)	120	89	**20,7**	xx	Marker 1KB7
1,7-2,6 Ho 3	Silt, gray	Banded; 14 ice bands up to 5 cm thick; interbeds 10-15 cm reticulated lens-like	MKh-KB7-4	375 interbed 382 (ice band)	81 218		xx xx	Segregated ice sample for isotope analysis
2,6-3,0 Ho 4	Silt, gray	Reticulated lens-like,	MKh-KB7-5			22,5		

Site: Baydzherakh KB8 Hight: 2,1 m ; width: 2 m situated below marker R.P. 5.1 **19,5 m**
Sampling date: 01.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
		As a whole : banded structure; small ice wedge 1-5 cm width						
< 0 - 0,1 Ho 1	Clayish silt, gray	Banded (10 ice bands), reticulated lens-like				16,5		
0,1-0,5 Ho 2	Cryoturbated soil horizon with a big peat inclusion (30 cm)							
0,5-0,6 Ho 3	Silt, gray	Banded						
0,6-1,0 Ho 4	Soil horizon with peat inclusions	fine reticulated lens-like	MKh-KB8-1 (soil) MKh-KB8-4 MKh-KB8-5 (peat)	126	103	**17,5**	-	Marker 1KB8
1,0-1,3	Silt, gray	Banded (2-5 cm thick), 10 rhythms	MKh-KB8-2	10	101		xx	**OSL-Probe BYK 7**
1,3-1,5 Ho 6	Cryoturbated soil horizon, grayish-brown with middle to red-brown patches, peat inclusions, twigs	incompletly broken ice bands, reticulated lens-like cryostructure, in addition small subverticalc ice lenses	MKh-KB8-3	210	133	**18,5**		Marker 2KB8, **sample for U/Th-dating**

Table A5-2: continuation

Site: Baydzherakh KB 9 Hight: 2 m ; width: 2 m situated below marker R.P. 5.2 **24,2 m**
Sampling date: 3.8. 98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
<0-0,5 Ho 1	Silt brownish-gray	Banded, interbeds reticulated lens-like	MKh-KB9-1	B 2	170		xx	Segregated ice sample for isotope analysis
0,5-0,8 Ho 2	Soil horizon, spotted, peaty, with wood remains, slightly rooted	Fine reticulated lens-like	MKh-KB9-2 MKh-KB9-3	148	64	22,2	(x)	Segregated ice sample for isotope analysis
0,8-1,6 Ho 3	Silt	Banded (3-4 bands), interlayers 5-15 cm thick	MKh-KB9-4	18	169	23	x	
1,6-2,0 Ho 4	Soil horizon, spotted, slightly rooted	Slightly banded, fine reticulated lens-like, in addition subvertical ice lenses	MKh-KB9-5 MKh-KB9-6	142	76	23,2	-	
> 2	Silt	Banded, reticulated lens-like						

Site: MKh 4.1 Hight: 2 m ; 5 m to the south of marker R.P. 5.3. **27,3 m NN**, situated directly at the top line
Sampling date: 03.08. 98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-0,4 Ho 1	Silt, grayish-brown, with shrub wood, peat inclusions	Banded, fine reticulated, lens-like, in addition subvertical ice lenses	MKh-4.1-1	281	63	25	xx	
0,5-1,0 Ho 2	Cryoturbated soil horizon, sandy-silty, interbedded sand layer (5 cm thick), micropolygonale wedges (20 cm long, 40-50 cm distance)		MKh-4.1-2 (sand) MKh-4.1-3 (silt)	101	60		xx	
1,0-1,4 Ho 3	Fine sandy silt, middle brown to grayish brown, spotted, wood	Horizontal, fine reticulated lens-like	MKh-4.1-4	15	57		xx	
1,4-1,5		Transition layer, diagonal ice lenses						
1,5-1,9		Activ layer						
1,9-2,0	Sod							

Table A5-2: continuation

Site: MKh 4.2 Sampling date: 03.08.98	Hight: 2 m ; 2 m in-front of marker R.P. 4.1 **36,7 m NN**							
Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-0,5 Ho 1	Silt	Banded, alternation of coarse reticulated lens-like and fine reticulated lens-like layers (10-15 cm); ice bands (2-3 cm) consist of dense fine ice layers	MKh-4.2-1	321	71	33	xx	Segregated ice for isotope analysis
0,5-1,0 Ho 2	Cryoturbated soil, wood remains	Fine reticulated lens-like with subvertical lenses	MKh-4.2-2 MKh-4.2-3	055	59	34	xx	Segregated ice for isotope analysis
1,0-1,3 Ho 3	Silt-medium sand alternation, cryoturbation, small sand wedges in distances of 5-10 cm		MKh-4.2-4 (sand)	154	40		xx	
1,31,7 Ho 4	Silt	Banded (s. Ho 1)		141	41		xx	
1,7-2,0	Active layer					35		

Site: MKh 4.3 Sampling date: 03.08.98	Hight: 1 m Baydzherakh on the top of the outcrop complex below marker R.P 4.1 **36,7 m NN**, backside of peat over the outcrop MKh 4.2; correspond to B-4 of Sweta Kuzmina							
Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice))	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-0,2 Ho 3	Cryoturbated soil , grayish- brown, peaty		MKh-4.3-1	185	104	35,7	xx	
0,2-0,6 Ho 2	Silt with small peat inclusions	Banded, bands consist of dense fine ice layers and lenses, interlayers reticulated lens-like	MKh-4.3-2	7	236		x	Segregated ice for isotope analysis
0,6-0,9 Ho 1	Peaty soil, peat wedges, the upper part: brownish decomposed (Ho 1a); the lower part: blackish brown, few decomposed, with re-mains of carex and shrubs (Ho 1b)		MKh-4.3-3 (black peat) MKh-4.3-4 (brownish peat)	215	115		-	
0,9-1,0	sod							

Table A5-2: continuation

Site: MKh 4.6, Sampling date: 09.08.98	Hight 2m; situated directly below the topline, at the marker R.P 4.6, to the left of an ice wedge	**37,6 m NN**						
Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
< 0-1,0	Silt	Lens-like						
1,0-1,3	Cryoturbated soil horizon, grayish brown, spotted, with peat inclusions		MKh-4.6-S-3 MKh-4.6-S-2 (peat)	101	207	36,6	-	**Sample for U/Th-dating**
1,3-1,5	Silt	Banded, ice bands 2-5 cm thick, interlayers reticulated lens-like	MKh-4.6-S-1	W10	288		-	
			MKh-4.6-14C-1 MKh-4.6-14C-2 MKh-4.6-14C-3 MKh-4.6-14C-4					Samples of S. Derivyagin

Site: MKh 4.12, Sampling date: 09.08.98	Hight: 4 m ; width: 4 m; near marker R.P. 4.12, contact of valley sand (loshkovy deposits) and ice complex	**26,1 m**						
Hight at the profile m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content	Altitude [m a.s.l.]	Carbonate content	Remarks
0-2 Ho 1 Ho 2	Fine sandy silt, brownish, with wood remains and peat inclusions	Banded, ice bands 2-5 cm thick, interlayers 5-15 cm thick and reticulated lens-like	MKh-4.12-S-1 MKh-4.12-S-2	4	126	to 24	x x	Segregated ice sample for isotope analysis
1-2 Ho 3	Discordant contact between ice complex and sandy horizon, South-dipping							
2-4 Ho 4 Ho 5	Fine sand with peat inclusions	Banded, diagonal reticulated lens-like	MKh-4.12-S-4 (sand) MKh-4.12-S-3 (peat)	B 3	107	26,1	x x	Segregated ice sample for isotope analysis **OSL-Sample BYK 11** Segregated ice sample for isotope analysis

Table A5-2: continuation

Site: MKh 1.6. Hight 1,5 m; peat horizon on the top of the outcrop complex, over the snow field, near marker R.P. 1.6 **17.1 m**
Sampling date: 09.08.98 study site situated at a recent frost crack with a small ice wedge

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
	Peat monolith from the active layer		MKh-1.6.0-1			17,1		
< 0-0,3	Clayish silt dark grayish-brown, cryoturbated, with peat inclusions	Banded, interlayers reticulated lens-like	MKh-1.6.1-1 (silt) MKh-1.6.1-2 (peat)	B 1	140	17		
0,3-1,5	Peat							
0,3-0,4	base of peat horizon		MKh-1.6.1-3					Pollen profile
0,4-0,5			MKh-1.6.1-4					
0,5-0,6			MKh-1.6.1-5					
0,6-0,7			MKh-1.6.1-6					
0,7-0,8			MKh-1.6.1-7					
0,8-0,9			MKh-1.6.1-8					
0,9-1,0			MKh-1.6.1-9					
1,0-1,1			MKh-1.6.1-10					
1,1-1,2			MKh-1.6.1-11					
1,2-1,3	peat at the base of active layer		MKh-1.6.1-12					
1,3-1,4			MKh-1.6.1-13					
1,4-1,5			MKh-1.6.1-14					

Site: MKh 1.7.2. Hight: 5 m; deposits situated on a big old ice wedge, corresponding to R 23; R 22
Sampling date: 18.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
< 0	Ice wedge							
0-1	Cryoturbated soil, reddish-brown, sandy, with wood remains and peat inclusions	Banded	MKh.1.7.2-S--4 (sand) MKh-1.7.2-5 (peat)					
1-3,5	Sand-silt alternations	Banded	MKh-1.7.2-3 (sand) MKh-1.7.2-2 (silt)					
3,5-4,5	Peat horizon on the top of PF		MKh-1.7.2-1					
4,5-5	actic layer							

Table A5-2: continuation

Site: MKh BR Sampling date: 07.08. 98	Hight: 2 m; Baydzherakh „Repro" corresponding to R16, below R.P 3.2 **16,7 m** medium part of the outcrop complex							
Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-1,5 m	Cryoturbated soil horizon with „humus"-wedges (40 cm); in the upper part many pieces of shrup wood	Irregular reticulated lens-like	MKh-BR-1 (wood) MKh-BR-2 (soil)			16,7		

Site: MKh HB 2 Sampling date: 07.08.98	Hight: 3 m; peat horizon of about 1m exposed in four neighbouring baydzherakhs (B. „Zayets"); **16,6 m**							
Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
<0 - 1,4	Clayish silt with peat inclusion, grass roots and wood remains	Banded, ice bands 2-5 cm thick, interlayers 5-24 cm thick and fine reticulated lens-like, with subvertical ice lenses	MKh-HB2-1	3	65		x x	**OSL-sample BYK 5**
1,4-1,5	Transitions horizon with higher peat and wood content	Banded	MKh-HB2-2					
1,5-2,4	Peat horizon, slightly decomposed moss peat, brown							
1,5-1,6			MKh-HB2-3					**Sample for U/Th-dating** Pollen profile
1,6-1,7			MKh-HB2-4					
1,7-1,8			MKh-HB2-5					
1,8-1,9			MKh-HB2-6					
1,9-2,0			MKh-HB2-7					
2,0-2,1			MKh-HB2-8					
2,1-2,2			MKh-HB2-9					
2,2-2,3			MKh-HB2-10					
2,3-2,4			MKh-HB2-11					
2,4-3,0	Thawed sediment					**16,6**		

Table A5-2: continuation

Site: MKh 3 — Hight: 3 m, situated below marker R.P. 3.1 **14 m**
Sampling date: 14.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
	Silt, gray	Banded, ice bands 5-10 cm thick, coarse reticulated lens-like; interlayers 20 -25 cm thick						a sequence of five sediment interlayers between ice bands was sampled **OSL sample BYK 4**
0.7-0,9	Silt		MKh-3-S-1					Segregated ice sample
0,9-1,2			MKh-3-S-2					Segregated ice sample
1,2-1,4			MKh-3-S-3					Segregated ice sample
1,4-1,7			MKh-3-S-4					Segregated ice sample
1,7-2,0			MKh-3-S-5					Segregated ice sample
			MKh-3-14C			10,5		sample of S. Derivayagin
			MKh-3.01			9,2		sample of S. Derivayagin

Site: MKh 7.1 — Hight: 2 m; south of the snow field; modern abrasion edge up to **2 m** above the sea level
Sampling date: 5./6.07.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0 -1,0	Fine sandy silt, gray	Banded, ice bands 2-5 cm thick, reticulated lens-like	MKh-7.1-S-3					
1,0-1,1	Clayish layer	Blocky reticulated						
1,1-1,5	Sandy silt with peat inclusions and wood remains	Reticulated lens-like, partly with subvertical ice lenses	MKh-7.1-S-2 MKh-7.1-S-1					
1,5-2,0	Slope sediments					4		

outcroup: MKh 1.1 — Hight: 1,5 m; 50 m to the north of the „thermo channel", modern abrasion edge up to **2 m** above the sea level
Sampling date: 07.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
	Fine sandy silt, wood remains, grass roots	Banded, ice bands 10 cm thick, interlayers fine reticulated lens-like, with subvertical ice lenses (up to 5 cm)						**OSL sample BYK 3**
0,4			MKh-1.1-1 MKh-1.1-3	23	55		xx	Segregated ice sample
1,4			MKh-1.1-2	9	62	3	xx	Segregated ice sample

Table A5-2: continuation

Site: MKh 1.2 — Hight: 1 m; on the left side of the „thermo channel", below Marker R.P. 1.2 **3,2 m**
Sampling date: 07.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-0,5	Silt	Banded						
0,5-0,65	Cryoturbated soil horizon, brownish-gray, pocket like deformed	Banded, irregularly fine reticulated lens-like	MKh-1.2-1	13	68		xx	Segregated ice sample
0,65-1,0	silt	ice rich, banded						

Site: MKh 6.1 — Hight: 2 m ; width: 5 m; at the northern end of the outcrop complex, modern abrasion edge **1-3 m** above the sea level
Sampling date: 06.08.98 — erosion discordance between ice complex deposits and alas deposits, above a big old ice wedge

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-1 Ho 1	Big ice wedge with a bented smaller and younger ice wedge							
left side 1,0-1,5 Ho 2	Clayish silt, gràyish-brown, with wood remains	Banded, ice bands 2-4 cm in distances of 5-20 cm	MKh-6.1-1 MKh-6.1-2 (wood)	7	118	1	xx	Segregated ice sample Segregated ice sample
right side 1,0-1,2 Ho 3	Medium sand at the discordance		MKh-6.1-3					Segregated ice sample
1,2-1,3 Ho 4	Allochthon peat with many pieces of wood		MKh-6.1-4					
1,3-1,5	Clayish silt, rooted, many organic remains in the upper part	Coarse reticulated lens-like, finer in the upper part	MKh-6.1.-5 MKh-6.1.-6 (peat)	154	80		xx	Segregated ice sample
1,5-2,0	Active layer, sod							

Site: MKh 6.3 — Hight: 2 m; modern abrasion edge **1-3 m** above the sea level; alas deposits to the north of the camp
Sampling date: 18.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
1,0	Silt with fine long roots	Banded, many long gas pores in the ice	MKh-6.3.-3					
1,3	Silt, gray		MKh-6.3-2					
1,5	Silt, dark gray		MKh-6.3-1					
1,6-2,0	Activ layer, peaty soil							

Table A5-2: continuation

Site: MKh 6.2 Hight: 3m; width: 5 m; modern abrasion edge **0-3 m** above the sea level, alas deposits between two younger ice wedges
Sampling date: 05./12.08. 98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
< 0	Big old ice wedge					0		
0-0,2	Silt	Fine reticulated lens-like						
0,2-0,4 Ho 1b	Fine to medium grained sand, peaty, with wood and peat inclusions	Coarse reticulated lens-like, lenses 1 cm thick and 5-15 cm long	MKh-6.2-4	21	62		-	
0,4-0,5 Ho 1a	Peaty root horizon,		MKh-6.2-3					
0,5-0,8 Ho 2	Medium to coarse grained sand, gravel, dark gray, ripples (1-2 cm high and 7-10 cm long)	Massive	MKh-6.2.-1	13	33		xx	**OSL sample BYK 1**
0,8-2,0 Ho 3	Fine to medium grained sand, dark gray, wood remains, small ripples (1 cm high, 5 cm long)	Massive	MKh-6.2-2 MKh-6.2-5 (wood)	11	58	2	xx	
2,0-2,1	Silt, transition zone	Diagonal cryostructure						
2,1-3,0 Ho 4	Moss peat, brown with various sediment content		MKh-6.2-6					
2,10-2,20			MKh-6.2-7					
2,20-2,30			MKh-6.2-8					
2,30-2,40			MKh-6.2-9					
2,40-2,45			MKh-6.2-10					
2,45-2,50			MKh-6.2-11					
2,50-2,55			MKh-6.2-12					
2,55-2,60			MKh-6.2-13					
2,60-2,65			MKh-6.2-14					
2,65-2,70			MKh-6.2-15					
2,70-2,75			MKh-6.2-16					
2,75-2,80			MKh-6.2-17					
2,80-2,85			MKh-6.2-18					

Table A5-2: continuation

Site: BYK BH2 Well on the top of the pingo „Mamontovy Bulgunyakh; depth: 6,55 m, high of the pingo **28 m NN**
Sampling date: 14.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
0-0,40	Loamy silt, active layer, recent soil,							
0,4-0,9 0,7-0,8 0,9	Silt, dark gray	Coarse lens-like, lenses 2-5 mm, downwards fine lens-like	 BYK-BH2-1 BYK-BH2-2		 42 37		 - -	
0,9-1,20 1,2	Sandy silt, gray, remains of shrub wood with FeOOH-films, authigenic Vivianit	Several thick ice lenses, between lenses massive structure, small ice nods	 BYK-BH2-3		 52		 -	
1,2-1,4 1,3-1,35	Peaty silt with sand lenses and lenses of allochtonous woody plant remains, Vivianit	Massive	 BYK-BH2-4		 38		 -	
1,4-1,8 1,6-1,65 1,7-1,75	Alternation of clayish fine sand and allochtonous peat material (reddish-brown plant chaff with shrub remains); lenses and interlayers of clay; spotted (gley)	Rare broken ice lenses in the upper part; more ice rich and massiv in the lower part	 BYK-BH2-5 BYK-BH2-6		 25 35		 - -	
1,8-2,3 2,0-2,1	Cross bedded sandy silt, gray; with lenses and layers of fine sand and reddish peat material, FeOOH-spots, FeOOH-films on plant remains	Irregularly distributed broken ice lenses; up to 2,1 m depth rare lenses 2-3 mm thick; in the lower part subhorizontal densly arranged lenses	 BYK-BH2-7		 35-42		 -	
2,3-2,5 2,3	Cross bedded sand-silt alternation; FeOOH-spots in contact to ice lenses	Broken ice lenses, 1-3 mm thick, more densly arranged	 BYK-BH2-8		 34		 -	
2,5-2,62	Silt, brownish-gray, with small fine sand lenses and FeOOH spots	Rare broken ice lenses, 5mm thick						
2,62-3,15 2,65 2,7 2,85-2,9 3,05	Silt, brownish-gray, big FeOOH-spots, shrub remains Ø up to 4 mm, in contact to ice lenses Fe-crusts, sand layer in the lower 10 cm	Several broken ice lenses, 2-7 mm thick	 BYK-BH2-9 BYK-BH2-10 BYK-BH2-11 BYK-BH2-12		 29 22		 - - - -	
3,1-3,45 3,15 3,25	Medium to coarse grained sand, unsorted, brownish- to reddish-brown, inclusions of clayish silt, shrub remains and plant chaff	Massive, rare lenses, coarse subhorizontal streaks and node-like inclusions of ice up to 1 cm; subvertikal ice streaks in contact between sand and silt	 BYK-BH2-13 BYK-BH2-14		 13 26		 - -	

Table A5-2: continuation

Site: BYK BH2 (Continuation) Well on the top of the pingo „Mamontovy Bulgunyakh; depth: 6,55 m, hight of the pingo **28 m** NN
Sampling date: 14.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
3,45-3,9 3,75	Cros bedded silt with lenses and layers of fine sand, partly with plant chaff, gray	Several subhorizontal thick ice streaks (4 mm), seldom broken fine ice lenses, in parts dense groups of very fine lenses occur	BYK-BH2-15		24		-	
3,9-4,2 3,9	Sandy silt, gray, with black points (decomposed organic matter or authigenic sulphides ?)		BYK-BH2-16		25			
4,2-4,4 4,3 4,4	Irregularly distributed sand and silt, blocky interweaved, several remains of shrub wood, FeOOH-spots	Diagonal broken lenses, in the lower part reticulated broken lenses	BYK-BH2-17 BYK-BH2-18		25		- -	
4,4-4,6 4,6	Clayish silty sand with plant chaff	Broken ice streaks, sediment very dense between ice streaks	BYK-BH2-19		22		-	
4,6-4,9	Clayish sandy silt with irregular sand inclusions, gray	Diagonal, lens-like, sediment very dense between ice lenses			38		-	
4,9-540 5,0	Sandy silt, gray, very dense	Diagonal orientated fine ice lenses, coarse subvertical streaks, strong FeOOH-film on contact faces between ice and sediment	BYK-BH2-20		26		-	
5,4-5,6	Silty sand, brownish-gray, very dense, impregnation of FeOOH in fissures	Massive						
5,6-6,3 5,6-5,7 5,9 6,3	Silt, grayish-brown, numerous little reddish and several light grayish spots, shrub remains, lower part more sandy with reddish spots	Rare broken fine lenses, in the lower part coarser lenses, diagonal orientated, local reticulated, FeOOH- film on contact faces between ice and sediment	BYK-BH2-21 BYK-BH2-22 BYK-BH2-23		27 28		- -	
6,3-6,55 6,45-6,55	Silt, irregularly gray to grayish-brown coloured, with little black inclusions, dense	Several coarse ice streaks with FeOOH-films; broken fine ice lenses	BYK-BH2-24		16-28		-	Ground temperature -11,8 °C

Table A5-2: continuation

Site: MB 1.1, coastal outcrop „Mamontovy Bysygasa", norther part of tbe alas Hight: 8,5 ; width: 4 m, **8-9 m NN**
Sampling date: 19.08.98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
Beach	Sand, rich in bones and gravels		MB-strand					
< 0	Clayish silt		MB-1.1-S-7					
3 - 4 (E)	Deformed sand and silt, with lenses of medium grained sand	Massive, low ice content, clayish silt with brecciated structure	MB-1.1-S-6 (sand) MB-1.1-S-5 (silt)					
4 - 5 (D) 5-5,2	deformed, fine sandy silt; fine grained sand with ripples of medium grained sand; tilted with discordance	Fine lens-like	MB-1.1-S-4					
5,2-6,5 (C)	Cryoturbated sandy soil with wood inclusions		MB-1.1-S-3 MB-1.1-S-2 (wood)					
6,5-7,5 (B)	Silt, with peat inclusions	Banded, reticulated						
7,5-8,5 (A)	Silt with a lot of peat inclusions	Massive	MB-1.1-S-1					
	Dark loose slope sediment		MB-1.2-14C					sample for Swetlana Kuzmina

Site: M, Cape Mammoth, outcrop similar to „Mamontovy Khayata"; one outcrop near the sea level (about 5 m a.s.l.)
Sampling date: 08.08.98 and a second near the topline (about 25 m a.s.l.) were sampled exemplarely

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
beach	Sand		Seesand					
base 0-0,3	Cryoturbated soil, brownish, spoted with peat inclusions		M-1.1-S-2 M-1.1-S-3 (peat)	191	104	5	-	
0,3-1,3	Silt, gray	Banded, coarse reticulated lens-like	M-1.1-S-1	17	154		xx	
1,3-2,0	Slope sediment with sand lenses and gravels		M-1.1-S-4					
top	Silt	Banded		B 2	89	25	xx	
	Peaty soil		M-1.2-14C-1	281	93		-	
300 m southern	Sandy slope sediment in a little erosional valley		M-1.3-S-1					

Table A5-2: continuation

Site: Bykovsky North; 6,7 km to the south of Cape Bykovsky; seà signal **28 m NN**
Sampling date: 16.08. 98

Hight at the profile [m]	Sediment description	Cryostructure	Sample number (sediment)	Box-Nr. (ice)	Ice content [%]	Altitude [m a.s.l.]	Carbonate content	Remarks
3 m below surface	Unfrozen sand (light-brown) with layers of silty organogenic materi-als		B-S-2b (sand) B-S-1 (silt)			25		**OSL-sample BYK 8**
5 m below surface	Erosional contact between silty ice complex deposits and unfrozen sands							
<0-0,5	Silt with wood remains	fine reticulated lens-like	B-S-4 B-S-5					
0,5-0,6	Cryoturbated transition horizon, sand and gravel							
0,6- >1,0	Sand with layers rich in organoge-nic material		B-S-3					**OSL-sample BYK 9**
Lower part: baydzherakh with·ice-rich silt, cryoturbated soil and peat inclusions						10		
	Silt, gray	ice-rich, fine reticulated lens-like	B-S-6					**OSL-sample BYK 10**
	Peat inclusion in soil horizon		B-S-7					

Table A5-3: List of bone samples submitted to the Radiocarbon Laboratory of the Geological Institute, Russian Academy of Sciences.

Laboratory Number	Locality	Elevation (a.s.l.)	Bone data-base No.	Taxon	Skeleton element	Preservation
Group "a" - bones found strictly in situ in the Mamontovy Khayata section						
GIN-9870	MKh main section, Stn. 550, Bdzh. "Ro", in situ	21.9 m	74	Rangifer tarandus (L.)	shed antler	fragment
GIN-9875	MKh main section, Stn. 580, Bdzh. in situ	26.0 m	520	Rangifer tarandus (L.)	skull with antler	fragment
GIN-9883	MKh main section, Stn. 540, Bdzh. "Ku", in situ	13 m	176	Rangifer tarandus (L.)	antler	2 fragments
GIN-9887	MKh main section, Stn. 760, Bdzh. "Lu", in situ	26.0 m	307	Mammuthus primigenius (Blum.)	femur	fragment juv.
GIN-9889	MKh main section, Stn. 500, Bdzh. D1, in situ	20.4 m	76	Mammuthus primigenius (Blum.)	tusk	fragment
GIN-9898	MKh - south, Stn.1450, fluvial-proluvial sands, in situ	Redeposited ? 4.5-5 m from the top of the outcrop.	306	Mammuthus primigenius (Blum.)	milk tusk	fragment
Group "b" - bones found on the surface of mud flows within the Mamontovy Khayata section, but at the locations, related to certain exposed parts of the cliff. Some bones in this group almost certainly came from particular baydzharakhs,						
GIN-9869	MKh main section, Stn. 550, beneath baydzharakh "Ro"	18-24 m	384	Rangifer tarandus (L.)	shed antler	fragment
GIN-9872	MKh main section, Stn. 575-625, bone field " L "	14-38 m	333	Bison priscus (Boj.)	radius	proximal fragments (2 pieces)
GIN-9873	MKh main section, Stn. 920-960, bone field "R"	20-32 m	424	Equus caballus L.	femur	
GIN-9874	MKh main section, Stn. 920-960, bone field "R"	20-32 m	431	Mammuthus primigenius (Blum.)	pelvis	fragment
GIN-9876	MKh main section, Stn. 575-625, bone field "L"	14-38 m	359	Equus caballus L.	humerus	
GIN-9878	MKh main section, Stn. 575-625, bone field "L"	14-38 m	360	Equus caballus L.	radius	
GIN-9879	MKh main section, Stn. 575-625, bone field "L"	14-38 m	332	Equus caballus L.	radius	proximal fragment
GIN-9880	MKh main section, Stn. 920-960, bone field "R"	20-32 m	549	Mammuthus primigenius (Blum.)	carpale IV-V	
GIN-9881	MKh main section, Stn. 690, beneath baydzharakh Z2	12-14 m	450	Mammuthus primigenius (Blum.)	metacarpal bone (metacarpale II)	
GIN-9882	MKh main section, Stn. 575-625, bone field "L"	14-38 m	329	Mammuthus primigenius (Blum.)	femur	fragment juv.
GIN-9885	MKh main section, Stn. 775-800, bone field "Q"	13-36 m	345	Bison priscus (Boj.)	tibia	
GIN-9886	MKh main section, Stn. 775-800, bone field "Q"	13-36 m	343	Equus caballus L.	humerus	distal fragment
GIN-9888	MKh main section, Stn. 900, beneath exposure MKh-3	9-10 (<14) m	346	Rangifer tarandus (L.)	tibia	
GIN-9890	MKh main section, Stn. 475-500, bone field "J"	10-25 m	380	Mammuthus primigenius (Blum.)	tusk	sample cut out
GIN-9891	MKh main section, Stn. 920-960, bone field "R"	20-32 m	421	Mammuthus primigenius (Blum.)	tibia	proximal fragment
GIN-9892	MKh main section, Stn. 920-960, bone field "R"	20-32 m	427	Mammuthus primigenius (Blum.)	humerus	fragment

Table A5-3: continuation

Laboratory Number	Locality	Elevation (a.s.l.)	Bone data-base No.	Taxon	Skeleton element	Preservation
GIN-9895	MKh main section, Stn. 700, between baydzharakhs Z1 and Z2	15-16 m	355	Mammuthus primigenius (Blum.)	tusk	sample cut out
GIN-9896	MKh main section, Stn. 810, beneath baydzharakh	12-15 m	358	Mammuthus primigenius (Blum.)	pelvis	fragment juv.
GIN-9897	MKh main section, Stn. 920-960, bone field "R"	20-32 m	432	Mammuthus primigenius (Blum.)	pelvis	fragment
GIN-9899	MKh main section, Stn. 640, secondary frozen	>18.4 m	73	Equus caballus L.	tibia (2 pieces)	fragment
GIN-9907	MKh main section, Stn. 625	24-38 m	453	Mammuthus primigenius (Blum.)	pelvis	
Group "d" - bones collected on the shore and shallow bars beneath the Mamontovy Khayata section						
GIN-9900	Shore, beginning of the MKh main section near a snow-patch		323	Mammuthus primigenius (Blum.)	atlas	
GIN-9903	shore and bar		218	Mammuthus primigenius (Blum.)	limb bone	fragment
GIN-9905	shore and bar		436	Mammuthus primigenius (Blum.)	humerus	proximal fragment
GIN-9908	shore and bar		513	Mammuthus primigenius (Blum.)	metacarpal bone (metacarpale III)	
Group "e" - bones collected on the shore beneath the Holocene section .... ("Holocene shore")						
GIN-9871	Holocene shore		595	Equus caballus L.	humerus	
GIN-9877	Holocene shore		500	Bison priscus (Boj.)	epistropheus (second cervical vertebra)	
GIN-9884	Holocene shore		469	Mammuthus primigenius (Blum.)	tibia	fragment
GIN-9894	Holocene shore		479	Bison priscus (Boj.)	atlas	
GIN-9901	Holocene shore		470	Mammuthus primigenius (Blum.)	tibia	fragment juv.
GIN-9902	Holocene shore		466	Mammuthus primigenius (Blum.)	scapula	2 fragments
GIN-9904	Holocene shore		467	Mammuthus primigenius (Blum.)	tusk	fragment
GIN-9906	Holocene shore		465	Mammuthus primigenius (Blum.)	ulna	proximal fragment
Group "f" - bones collected at the other sites on the Bykovsky Peninsula or in the Lena Delta						
GIN-9893	Lake Mamont, shore		522	Mammuthus primigenius (Blum.)	mandible, symphysis, no teeth	fragment

Table A5-4: List of samples collected for absolute age determinations.

samples for AMS-dating

	sample	material	site	date	coll.	weight (mg)
1	Mkh-K1-14C-1 (Mkh-K1-16 ?)	peat at situ (grass)	baydzharakh "Kuno"; profil 1a; 4,9 m	29.07.1998	LS/CS	166
2	Mkh-K1- 14C-2 (Mkh-K1-12 ?)	dwarf shrub remains	baydzharakh "Kuno"; profil 1a; 4,1-4,25 m	29.07.1998	LS/CS	284
3	Mkh-KB1-14C-2	dwarf shrub remains	baydzharakh KB1 , horizon 2	30.07.1998	LS/CS	145
4	Mkh-KB1-4	wood remains	KB1, horizon 4	30.07.1998	LS/CS	142
5	Mkh-KB2-14C-2	dwarf shrub remains	KB2; soil horizon; 1,4-1,8; marker 2Kb2 (14,8 m)	30.07.1998	LS/CS	489
6	Mkh-KB3-14C-1	peat inclusion (wood remains)	KB3, horizon 1	01.08.1998	LS/CS	128
7	Mkh-KB4-4 (gastropod-horiz.)	grass roots	KB4, soil horizon marker 2KB4 (16,0 m)	01.08.1998	VT	48
8	Mkh-KB4-6	wood remains	KB4; 3,7-4,2m	01.08.1998	VT	419
9	MKh-KB5-14C-2 Holz	shrub remains (peat at situ)	KB5; soil horizon marker 2KB5 (15,9 m)	30.07.1998	LS/CS	110
10	MKh-KB5-14C-2 peat	peat remains (peat at situ)	KB5; soil horizon marker 2KB5 (15,9 m)	30.07.1998	LS/CS	426
11	Mkh-KB6-14C-3	peat, strongly rooted	KB6, horizon 3	02.08.1998	LS/CS	163
12	Mkh-KB7-14C-3a	dwarf shrub remains	KB7, peat inclusions at horizon 2	01.08.1998	LS/CS	84
13	MKh-KB7-14C-5a	wood remains from peat	KB7, peat inclusions at horizon 4	01.08.1998	LS/CS	238
14	MKh-KB8-14C-3	wood remains	KB8, horizon 6 (marker 2KB8 18,5 m)	01.08.1998	LS/CS	425
15	Mkh-KB8-4	peat inclusion	KB8; horizon 4 (marker 1KB8 17,5 m)	01.08.1998	LS/CS	302
16	Mkh-KB9-3	peaty soil	KB9; horizon 2	03.08.1998	LS/CS	144
17	Mkh-KB9-6	sSilt with roots	KB9; horizon 4	03.08.1998	LS/CS	52
18	Mkh-4.2-14C-3a	wood remains	Mkh 4.2; horizon 2 (R.P. 4.1)	03.08.1998	LS/CS	42
19	Mkh-4.3-14C-4 Holz	peat (wood remains))	baydzharakh below R.P. 4.1	03.08.1998	LS/CS	31
20	MKh-4.6-14C-1	peat			AD	711
21	Mkh-4.12-S-2a	wood and root remains	Mkh 4.12; at marker R.P. 4.12; peat inclusions at horizon 1	09.08.1998	LS/CS	45
22	Mkh-1.6.1-2	peat	Mkh 1.6; peat inclusion at lower silt	09.08.1998	LS/CS	296
23	Mkh-1.6.1-3	peat	Mkh 1.6; base of peat horizon	09.08.1998	LS/CS	165
24	Mkh-1.7.2.-14C-5 Holz	peat (wood remaat)	Mkh 1.7.2, peat inclusion at cryoturbated soil	18.08.1998	LS	84
25	Mkh-B-Rippe-14C-2	dwarf wood remains	baydzharakh "Rebro"; 0,5 m below marker R.P. 3.6.	07.08.1998	LS/CS	964
26	Mkh-HB2-2	peat	baydzharakh HB2; transition horizon silt/peat	07.08.1998	LS/CS	177
27	Mkh-3-14C	peat lense	Mkh 3; right of the ice wedge; 10,5 m a.s.l.	31.07.1998	AD	389
28	Mkh-7.1.-S-2	wood and root remains	Mkh 7.1; 1,1-1,5 m; beach level	06.08.1998	LS	183
29	Mkh-1.1.-2	grass roots	Mkh 1.1; ice rich silt; near the ice channel	07.08.1998	LS/CS	222

Table A5-4: continuation

samples for AMS-dating (continuation)

	sample	material	site	date	coll.	(mg)
30	Mkh-1-2-14C-1	peat with wood remains	a.s.l.		AD/HM	156
31	Mkh-6.1-2	wood remains	Mkh 6.1; at horizon 2; silt at the contact	06.08.1998	LS/CS	108
32	Mkh-6.1.-14C-6	peat inclusions	Mkh 6.1; at horizon 6	06.08.1998	LS/CS	131
33	Mkh-6.2.-14C-5	Holzrest	Mkh 6.2 at horizon 3, fS-mS ripples	06.08.1998	LS/CS	239
34	Mkh-6.2.14C-3	peaty root horizon	Mkh 6,2; horizon 1b	06.08.1998	LS/CS	139
35	Mkh-6.2.-14C-6	peat	Mkh 6.2; base of peat horizon, horizon 4	06.08.1998	LS/CS	413
36	Mkh-6.3-1	plant remains	alas deposits northern of the camp	18.08.1998	LS/CS	64
37	Mkh-a-14C-1	coarse shrub wood	Ivashkat river; 25 m a.s.l.		AD	1224
38	MB 1.1-S2	wood remains	MB 1.1; profil C; "holocen outcrop"	19.08.1998	LS	241
39	ML-14C-1	shrub wood	Mammut-See, lake terrace 5m	16.08.1998	VT	383
40	BYK-A2-I-2	plant and wood remains from ice wedge BYK-A2	ice wedge at alas	ice srew	HM	12.9
41	BYK-A2-I-58	plant and wood remains from ice wedge BYK-A2	ice wedge at alas	ice srew	HM	21.2
42	BYK-A2-89a	plant and wood remains from ice wedge BYK-A2	ice wedge at alas	motor saw	HM	43.9
43	BYK-A2-Be 8/9	plant and wood remains from ice wedge BYK-A2	ice wedge at alas	motor saw	HM	10.4
44	BYK-A2-Be-3	plant fibre from ice wedge BYK-A2	ice wedge at alas	motor saw	HM	4.3
45	MKh-5-I-11	plant and wood remains from ice wedge MKh-5	ice wedge at ice complex	motor saw	HM	7.3
46	MKh-4.6-I-47	plant and wood remains from ice wedge MKh-4.6	ice wedge at ice complex	ice srew	HM	14

Table A5-4: continuation

samples for conventional radiocarbon dating

	sample	material	site	date	coll.	weight (mg)
1	MKh-6.2.-8 / 2,2-2,3	peat	alas	12.08.1998	CS/LS	12
2	MKh-6.2.-12 / 2,50-2,55	peat	alas	12.08.1998	CS/LS	12
3	MKh-6.2.-17 / 2,75-2,80	peat	alas	12.08.1998	CS/LS	22
4	MKh-HB2-4 / 1,6-1,7	peat	peat horizon at baydzherakh HB 2	07.08.1998	CS/LS	5
5	MKh-HB2-8 / 2,0-2,1	peat	peat horizon at baydzherakh HB 2	07.08.1998	CS/LS	5
6	MKh-HB2-10 / 2,2-2,3	peat	peat horizon at baydzherakh HB 2	07.08.1998	CS/LS	10
7	MKh-1.6.1-4 / 0,4-0,5	peat	peat horizon at the top of ice complex	09.08.1998	CS/LS	9
8	MKh-1.6.1-7 / 0,7-0,8	peat	peat horizon at the top of ice complex	09.08.1998	CS/LS	13
9	MKh-1.6.1-10 / 1,0-1,1	peat	peat horizon at the top of ice complex	09.08.1998	CS/LS	10
10	MKh-4.3-4 / 0,6-0,9	peat	peat horizon at the top of ice complex	09.08.1998	CS/LS	4
11	Mkh4-^{14}C-1	peat	between marker RP. 4.4 and 4.3, 39 m a.s.l.		VK	
12	Mkh4-^{14}C-2	peat	between marker R.P. 4.3 and 4.2; 38 m a.s.l.		VK	
13	Mkh4-^{14}C-8	peat	between marker R.P. 4.3 and 4.2; 20 m a.s.l.		VK	
14	Mkh4-^{14}C-7	peat	between marker R.P. 4.3 and 4.2; 16 m a.s.l.		VK	
15	Mkh-1.5.-^{14}C-5	peat	between marker R.P. 1,5 and 1.6.; 20 m a.s.l.		VK	
16	Mkh-1.6-^{14}C-6	peat	between marker R.P. 1,5 and 1.6.; 15 m a.s.l.		VK	
17	Mkh-alas-14C-4	peat	Mamontovy Bysagasa, alas, 1 m a.s.l.		VK	
18	Mkh-alas-14C-3	peat	Mamontovy Bysagasa, alas, 400m ; 3 m a.s.l.		VK	

Table A5-4: continuation

samples for OSL-dating

sample	material	position a.s.l. / site	date
	outcrop complex "Mamontovy Khayata"		
BYK 1	coarse grained sand of alas deposit	~1,5 m / MKh-6.2-1; above old ice wedge	13.08.1998
BYK 2	wood bearing sandy silt	~1 m / near MKh-7.1, behind snow patche	14.08.1998
BYK 3	ice riche silt	~2 m / near MKh-1.1.	14.08.1998
BYK 4	ice rich silt; about	~14 m / MKh-3-S-5	14.08.1998
BYK 5	soil horizon; silt with inclusions of peat and wood	~14,5 m / MKh-HB2-1	14.08.1998
BYK 6	ice rich silt	~ 9 m / MKh-K1 (1,5-1,8); base of baydzherakh "Kuno"	15.08.1998
BYK 7	ice rich silt	~18 m / MKh-KB8-2	15.08.1998
BYK 11	fine grained sand	~26 m / MKh-4.12-S-4	18.08.1998
	outcrop "Bykovsky North"		
BYK 8	unfrozen sand (Bykovsky North)	~25 m / B-S-2b	16.08.1998
BYK 9	frozen sand near the contact of ice complex deposit	~23 m / B-S-3	16.08.1998
BYK 10	silt, ice rich	~ 10 m / B-S-6	16.08.1998

samples for U/Th-dating

sample	material	position a.s.l.	date
Mkh-4.6.-S-2	peat inclusion at the top	36,6 m	09.08.1998
Mkh- KB8-3	peat inclusion at soil horizon baydzharakh KB8	18,5 m	15.08.1998
MKh-KB6-7	horizon with many peat inclusion near the top	18 m	02.08.1998
MKh-HB2-3	base of peat interlayer baydzharakh HB2	ca. 15,6 m	15.08.1998
MKh-K1-(5)	peat inclusion 1,5 m left of younger ice wedge	ca 10 m	15.08.1998

Table A5-5: List of bone samples.

Data-base No.	Field label	Taxon	Skeleton element	Preservation	Loc. type *)	Locality	Elevation (a.s.l.)	Notes**)
1	2	3	4	5	6	7	8	9
1	MKh - O 1	Mammuthus primigenius (Blum.)	tarsale 4-5		d	shore and bar		C14
2	MKh - O 2	Rangifer tarandus (L.)	antler	fragment	d	shore and bar		
3	MKh - O 3	Rangifer tarandus (L.)	shed antler	fragment (cut by man)	d	shore and bar		
4	MKh - O 4	Rangifer tarandus (L.)	antler	fragment	d	shore and bar		
5	MKh - O 5	Phocidae gen.***)	pelvis	left half	d	shore and bar		
6	MKh - O 6	Mammuthus primigenius (Blum.)	os carpi ulnare		d	shore and bar		C14
7	MKh - O 7	Rangifer tarandus (L.)	scapula	fragment	d	shore and bar		
8	MKh - O 8	Mammuthus primigenius (Blum.)	milk tusk		d	shore and bar		C14
9	MKh - O 9	Mammuthus primigenius (Blum.)	tooth lower, non-M3	fragment	d	shore and bar		
10	MKh - O 10	Mammuthus primigenius (Blum.)	tooth M2 lower, sin.		d	shore and bar		
11	MKh - O 11	Mammuthus primigenius (Blum.)	mandible, symphysis	fragment	d	shore and bar		
12	MKh - O 12	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
13	MKh - O 13	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
14	MKh - O 14	Mammuthus primigenius (Blum.)	tooth lower ?	fragment	d	shore and bar		
15	MKh - O 15	Mammuthus primigenius (Blum.)	tooth	fragment	d	shore and bar		
16	MKh - O 16	Mammuthus primigenius (Blum.)	tooth M1 lower	fragment	x			
17	MKh - O 17	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
18	MKh - O 18	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
19	MKh - O 19	Mammuthus primigenius (Blum.)	tooth M3 (?) lower dex.	fragment	d	shore and bar		
20	MKh - O 20	Mammuthus primigenius (Blum.)	tooth dP4 or M1 upper		d	shore and bar		
21	MKh - O 21	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
22	MKh - O 22	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
23	MKh - O 23	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
24	MKh - O 24	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
25	MKh - O 25	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
26	MKh - O 26	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
27	MKh - O 27	Equus caballus L.	mandible branch sin.	fragments (2)	d	shore and bar		
28.1	MKh - O 28ÿ	Equus caballus L.	mandible, incisor part	fragment	d	shore and bar		
28.2	MKh - O 28⁄	Equus caballus L.	upper tooth		d	shore and bar		

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
29	MKh - O 29	Equus caballus L.	upper tooth	fragment	d	shore and bar		
30	MKh - O 30	Equus caballus L.	upper tooth P2	fragment	d	shore and bar		
31	MKh - O 31	Equus caballus L.	maxilla, incisor part	fragment	d	shore and bar		
32	MKh - O 32	Bison priscus (Boj.)	upper tooth M		d	shore and bar		
33	MKh - O 33	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
34	MKh - O 34	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
35	MKh - O 35	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
36	MKh - O 36	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
37	MKh - O 37	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
38	MKh - O 38	Equus caballus L.	phalanx II		d	shore and bar		
39	MKh - O 39	Equus caballus L.	metacarpal bone (Mc III)	fragment	d	shore and bar		
40	MKh - O 40	Equus caballus L.	phalanx III (hoof)		d	shore and bar		
41	MKh - O 41	Mammuthus primigenius (Blum.)	limb bone - articulation surface	fragment	d	shore and bar		C14
42	MKh - O 42	Mammuthus primigenius (Blum.)	carpal bone	fragment	d	shore and bar		C14
43	MKh - O 43	Mammuthus primigenius (Blum.)	phalanx I (1 or 2)		d	shore and bar		
44	MKh - O 44	Mammuthus primigenius (Blum.)	os pisiforme		d	shore and bar		
45	MKh - O 45	Mammuthus primigenius (Blum.)	astragalus	fragment	d	shore and bar		C14
46	MKh - O 46	Mammuthus primigenius (Blum.)	patella		d	shore and bar		C14
47	MKh - O 47	Mammuthus primigenius (Blum.)	astragalus		d	shore and bar		C14
48	MKh - O 48	Mammuthus primigenius (Blum.)	calcaneus		d	shore and bar		C14
49	MKh - O 49	Rangifer tarandus (L.)?	humerus	distal fragment	d	shore and bar		
50	MKh - O 50	Bison priscus (Boj.)	calcaneus	juv.	d	shore and bar		
51	MKh - O 51	Rangifer tarandus (L.)?	radius	fragment (diaphys), juv.	d	shore and bar		
52	MKh - O 52	Equus caballus L. (small)	phalanx I		d	shore and bar		
53	MKh - O 53	Equus caballus L.	ulna		d	shore and bar		
54	MKh - O 54	Equus caballus L.	metacarpal bone (Mc III)	fragment	d	shore and bar		
55	MKh - O 55	Equus caballus L.	phalanx II		d	shore and bar		
56	MKh - O 56	Bison priscus (Boj.)	phalanx I (hind limb)		d	shore and bar		
57	MKh - O 57	Equus caballus L.	scapula	fragment	d	shore and bar		
58	MKh - O 58	Bison priscus (Boj.) (small)	radius	distal fragment	d	shore and bar		
59	MKh - O 59	Rangifer tarandus (L.)	ulna		d	shore and bar		
60	MKh - O 60	Bison priscus (Boj.)	radius	proximal fragment	d	shore and bar		
61	MKh - O 61	Rangifer tarandus (L.)	radius	proximal fragment	d	shore and bar		
62	MKh - O 62	Rangifer tarandus (L.)	antler		x			

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
63	MKh - O 63	Bovidae gen. ****) (large)	humerus	distal fragment	d	shore and bar		
64	MKh - O 64	Mammuthus primigenius (Blum.)	radius	proximal fragment	d	shore and bar		C14
65	MKh - O 65	Rangifer tarandus (L.)	tibia	proximal fragment	d	shore and bar		
66	MKh - O 66	Rangifer tarandus (L.)	radius	distal fragment	d	shore and bar		
67	MKh - O 67	Bison priscus (Boj.)	radius	proximal fragment	d	shore and bar		
68	MKh - O 68	Rangifer tarandus (L.)	shed antler	fragment, juv.	d	shore and bar		
69	MKh - O 69	Equus caballus L.	metacarpal bone (Mc III)		d	shore and bar		
70	MKh - O 70	Equus caballus L.	radius	distal fragment	d	shore and bar		
71	MKh - O 71	Rangifer tarandus (L.)?	calcaneus	juv.	d	shore and bar		
72	MKh - O 72	Equus caballus L.	phalanx II		d	shore and bar		
73	MKh - O 73	Equus caballus L.	tibia (2 pieces)	fragment	b	MKh main section, secondary frozen	>18.4 m	GIN-9899
74	MKh - O 74	Rangifer tarandus (L.)	shed antler	fragment	a	MKh main section, in situ, baydzharakh "Rog"	21.9 m	GIN-9870
75	MKh - O 75	Mammalia gen. *****)	limb bone	fragments (4)	a	MKh main section, in situ	17.4 m	AMS only
76	MKh - O 76	Mammuthus primigenius (Blum.)	tusk	fragment	a	in situ, MKh main section, baydzharakh D1	20.4 m	GIN-9889
77	MKh - O 77	Lepus sp.	pelvis, sacrum, vertebrae (4), ribs (4)	fragments	a	MKh main section, in situ, baydzharakh G2	18.4 m	AMS only
80	MKh - O 80	Lepus sp.	femur	proximal fragment	a	MKh main section, in situ, baydzharakh G3	15.5 m	AMS only
81	MKh - O 81	Lepus sp.	calcaneus		a	MKh main section, in situ, baydzharakh G8	16.5 m	AMS only
82	MKh - O 82	Lepus sp.	mandible (2 stems)		b	MKh main section, beneath baydzharakh "Zayats"	12-15 m	AMS only
83	MKh - O 83	Lepus sp.	mandible branch	fragment	b	MKh main section, beneath baydzharakh near "Zayats"	12-15 m	AMS only
84	MKh - O 84	Lepus sp.	phalanx I		c	MKh main section		
86	MKh - O 86	Bovidae gen. ****)	horn sheet	fragment	b	MKh main section, at the foot of baydzharakh B5	13-14 m (ca)	AMS only
88	MKh - O 88	Mammuthus primigenius (Blum.)	mandible with two heavily worn teeth M3		d	shore and bar		

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
89	MKh - O 89	Mammuthus primigenius (Blum.)	mandible (left stem) with heavily worn tooth M3		d	shore and bar		
90	MKh - O 90	Bison priscus (Boj.)	thoracic vertebra		d	shore and bar		
91	MKh - O 91	Rangifer tarandus (L.)	antler	fragment	d	shore and bar		
92	MKh - O 92	Mammuthus primigenius (Blum.)	upper tooth	fragment	d	shore and bar		
93	MKh - O 93	Equus caballus L.	humerus	distal fragment	d	shore and bar		
94	MKh - O 94	Rangifer tarandus (L.)	pelvis	fragment	d	shore and bar		
95	MKh - O 95	Mammuthus primigenius (Blum.)	tooth M3 upper	fragment	d	shore and bar		
96	MKh - O 96	Mammuthus primigenius (Blum.)	upper tooth	fragment	d	shore and bar		
97	MKh - O 97	Bison priscus (Boj.)	tibia	proximal fragment	d	shore and bar		
98	MKh - O 98	Equus caballus L.	thoracic vertebra		d	shore and bar		
99	MKh - O 99	Rangifer tarandus (L.)	shed antler	fragment	d	shore and bar		
100	MKh - O 100	Bison priscus (Boj.) (large)	radius		f	Cape Mamont, shore		
101	MKh - O 101	Equus caballus L.	femur	fragment	f	Cape Mamont, shore		
102	MKh - O 102	Equus caballus L. (large)	tibia	with remains of soft tissues	f	Cape Mamont, shore		
103	MKh - O 103	Rangifer tarandus (L.)	humerus	distal fragment	f	Cape Mamont, shore		
104	MKh - O 104	Bison priscus (Boj.)	lumbar vertebra		f	Cape Mamont, shore		
105	MKh - O 105	Bison priscus (Boj.)	atlas		f	Cape Mamont, shore		
106	MKh - O 106	Rangifer tarandus (L.)	humerus		d	Shore, beginning of the MKh main section near the snow-patch		
107	MKh - O 107	Rangifer tarandus (L.)	humerus	distal fragment	d	Shore, beginning of the MKh main section near the snow-patch		
109	MKh - O 109	Rangifer tarandus (L.)	metacarpal bone		d	Shore, beginning of the MKh main section near the snow-patch		
110	MKh - O 110	Bison priscus (Boj.)	humerus		d	Shore, beginning of the MKh main section near the snow-patch		
111	MKh - O 111	Rangifer tarandus (L.)	atlas		f	?Cape Mamont, shore		
112	MKh - O 112	Bison priscus (Boj.) (large)	atlas		d	Shore, beginning of the MKh main section near a snow-patch		

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
113	MKh - O 113	Carnivora gen.	cranium	fragment	d	shore		
114	MKh - O 114	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
115	MKh - O 115	Rangifer tarandus (L.)	metapodium	distal fragment	d	shore and bar		
116	MKh - O 116	Rangifer tarandus (L.)	metatarsal bone	proximal fragment	d	shore and bar		
117	MKh - O 117	Rangifer tarandus (L.)	metatarsal bone	proximal fragments (2 pieces)	d	shore and bar		
118	MKh - O 118	Equus caballus L.	os cuneiforme		d	shore and bar		
119	MKh - O 119	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
120	MKh - O 120	Bison priscus (Boj.)	humerus	distal fragment	d	shore and bar		Trashed
121	MKh - O 121	Mammuthus primigenius (Blum.)	lower tooth	fragment	d	shore and bar		C14
122	MKh - O 122	Bison priscus (Boj.)?	metapodium	fragment	d	?shore and bar		
123	MKh - O 123	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
124	MKh - O 124	Rangifer tarandus (L.)	cervical vertebra		d	shore and bar		
125	MKh - O 125	Equus caballus L.	ulna	fragment	d	shore and bar		
126	MKh - O 126	Equus caballus L.	side metatarsal bone (Mt II)		d	shore and bar		
127	MKh - O 127	Rangifer tarandus (L.)	antler	fragment	d	shore and bar		Trashed
128	MKh - O 128	Rangifer tarandus (L.)	antler	fragment	d	shore and bar		Trashed
129	MKh - O 129	Equus caballus L.	phalanx III (hoof)	fragment	d	shore and bar		
130	MKh - O 130	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
131	MKh - O 131	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
132	MKh - O 132	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
133	MKh - O 133	Mammuthus primigenius (Blum.)	tibia	distal fragment	d	shore and bar		C14
134	MKh - O 134	Phocidae gen.***)	cranium	fragment	d	shore and bar		
135	MKh - O 135	Phocidae gen.***)	cranium	fragment	d	shore and bar		
136	MKh - O 136	Phocidae gen.***)	cranium, ear region	fragment	d	shore and bar		
137	MKh - O 137	Equus caballus L.	upper tooth		d	shore and bar		
138	MKh - O 138	Equus caballus L.	upper tooth		d	shore and bar		
139	MKh - O 139	Equus caballus L.	upper tooth	fragment	d	shore and bar		
140	MKh - O 140	Equus caballus L.	upper tooth		d	shore and bar		
141	MKh - O 141	Equus caballus L.	upper tooth	fragment	d	shore and bar		
142	MKh - O 142	Equus caballus L.	upper tooth (deeply worn)		d	shore and bar		
143	MKh - O 143	Equus caballus L.	lower tooth		d	shore and bar		
144	MKh - O 144	Equus caballus L.	lower tooth		d	shore and bar		

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
145	MKh - O 145	Equus caballus L.	lower tooth		d	shore and bar		
146	MKh - O 146	Equus caballus L.	lower tooth	fragment	d	shore and bar		
147	MKh - O 147	Equus caballus L.	astragalus		d	shore and bar		
148	MKh - O 148	Equus caballus L.	upper tooth	fragment	d	shore and bar		
149	MKh - O 149	Bison priscus (Boj.)?	lower tooth	fragment	d	shore and bar		
150	MKh - O 150	Equus caballus L.	upper tooth	fragment	d	shore and bar		Trashed
151	MKh - O 151	Bison priscus (Boj.)?	upper tooth	fragment	d	shore and bar		
152	MKh - O 152	Equus caballus L.	upper tooth	fragment	d	shore and bar		Trashed
153	MKh - O 153	Equus caballus L.?	upper tooth	fragment	d	shore and bar		
154	MKh - O 154	Bison priscus (Boj.)	upper tooth	fragment	d	shore and bar		
155	MKh - O 155	Equus caballus L.	upper tooth	fragment	d	shore and bar		Trashed
156	MKh - O 156	Equus caballus L.	incisor	fragment	d	shore and bar		Trashed
157	MKh - O 157	Rangifer tarandus (L.)	lower tooth	fragment	d	shore and bar		
158	MKh - O 158	Phocidae gen.***)	mandible branch sin.		d	shore and bar	Recent	
159	MKh - O 159	Phocidae gen.***)	mandible branch dex.		d	shore and bar	Recent	
160	MKh - O 160	Bison priscus (Boj.)	phalanx I		d	shore and bar		
161	MKh - O 161	Mammuthus primigenius (Blum.)	tooth	fragment	d	shore and bar		C14
162	MKh - O 162	Lepus sp.	femur	fragment	d	shore and bar		
163	MKh - O 163	Phocidae gen.***)	limb bone	fragment	d	shore and bar		
164	MKh - O 164	Lepus sp.	mandible branch		d	shore and bar		
165	MKh - O 165	Mammalia gen. *****)	limb bone	fragment juv.	d	shore and bar		Trashed
166	MKh - O 166	Rangifer tarandus (L.) ?	pelvis	fragment	d	shore and bar		
167	MKh - O 167	Equus caballus L.	astragalus		d	shore and bar		
168	MKh - O 168	Bison priscus (Boj.)	os magnum		d	shore and bar		
169	MKh - O 169	Equus caballus L.	phalanx III (hoof)		d	shore and bar		
170	MKh - O 170	Bison priscus (Boj.)	femur	distal fragment	d	shore and bar		
171	MKh - O 171	Mammuthus primigenius (Blum.)	ulna	fragment juv.	d	shore and bar		
172	MKh - O 172	Mammuthus primigenius (Blum.)	ulna	fragment	d	shore and bar		C14
173	MKh - O 173	Mammuthus primigenius (Blum.)	vertebra, spine		d	shore and bar		Trashed
174	MKh - O 174	Phocidae gen.***)	cranium, ear region	fragment	d	shore and bar		
175	MKh - O 175	Rangifer tarandus (L.)	pelvis	fragment	d	shore and bar		
176	MKh - O 176	Rangifer tarandus (L.)	antler	2 fragments	a	MKh main section, in situ, baydzharakh "Kuno", 4.5 m from the foot of "Kuno"	13 m	GIN-9883
177	MKh - O 177	Rangifer tarandus (L.)	tooth		f	Arga, Nikolay Lake	Recent	Trashed

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
178	MKh - O 178	Mammuthus primigenius (Blum.)	limb bone	fragment	d	shore and bar		C14
179	MKh - O 179	Mammuthus primigenius (Blum.)	rib	fragment	d	shore and bar		Trashed
180	MKh - O 180	Mammuthus primigenius (Blum.)	limb bone	fragment	d	shore and bar		C14
181	MKh - O 181	Bison priscus (Boj.)	thoracic vertebra		d	shore and bar		
182	MKh - O 182	Mammalia gen ***)	rib	fragment	d	shore and bar		Trashed
183	MKh - O 183	Mammalia gen ***)	rib	fragment	d	shore and bar		Trashed
184	MKh - O 184	Mammuthus primigenius (Blum.)	large limb bone	fragment	d	shore and bar		Trashed
185	MKh - O 185	Mammalia gen ***)	rib	fragment	d	shore and bar		Trashed
186	MKh - O 186	Mammalia gen ***)	rib	fragment	d	shore and bar		Trashed
187	MKh - O 187	Mammuthus primigenius (Blum.)	limb bone	fragment	d	shore and bar		C14
188	MKh - O 188	Mammuthus primigenius (Blum.)	vertebra, spine		d	shore and bar		C14
189	MKh - O 189	Mammuthus primigenius (Blum.)	limb bone	fragment	d	shore and bar		Trashed
190	MKh - O 190	Mammuthus primigenius (Blum.)	rib	fragment	d	shore and bar		C14
191	MKh - O 191	Mammalia gen ***)	rib	fragment	d	shore and bar		Trashed
192	MKh - O 192	Mammuthus primigenius (Blum.)	os carpi radiale (lunatum)		d	shore and bar		C14
193	MKh - O 193	Mammuthus primigenius (Blum.)	vertebra		d	shore and bar		C14
194	MKh - O 194	Mammuthus primigenius (Blum.)	limb bone	fragment	d	shore and bar		
195	MKh - O 195	Rangifer tarandus (L.)	pelvis	fragment	d	shore and bar		
196	MKh - O 196	Mammuthus primigenius (Blum.)	vertebra		d	shore and bar		C14
197	MKh - O 197	Lepus sp.	tibia	distal fragment	d	shore and bar		
198	MKh - O 198	Mammuthus primigenius (Blum.)	tooth	fragment	d	shore and bar		C14
199	MKh - O 199	Equus caballus L.	upper milk tooth		d	shore and bar		
200	MKh - O 200	Mammuthus primigenius (Blum.)	epistropheus (second cervical vertebra)		d	shore and bar		C14
201	MKh - O 201	Rangifer tarandus (L.)	phalanx I		d	shore and bar		
202	MKh - O 202	Mammuthus primigenius (Blum.)	os carpale III		d	shore and bar		C14
203	MKh - O 203	Mammuthus primigenius (Blum.)	limb bone - articulation	fragment	d	shore and bar		C14
204	MKh - O 204	Mammuthus primigenius (Blum.)	limb bone - articulation surface	fragment	d	shore and bar		C14
205	MKh - O 205	Bison priscus (Boj.) ?	tibia	distal fragment	d	shore and bar		
206	MKh - O 206	Bison priscus (Boj.) ?	humerus	fragment juv.	d	shore and bar		
207	MKh - O 207	Mammuthus primigenius (Blum.)	cranium (squamosum)	fragment	d	shore and bar		
208	MKh - O 208	Mammuthus primigenius (Blum.)	vertebra		d	shore and bar		C14
209	MKh - O 209	Mammuthus primigenius (Blum.)	astragalus		d	shore and bar		C14

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
210	MKh - O 210	Mammuthus primigenius (Blum.)	femur	distal fragment	d	shore and bar		C14
211	MKh - O 211	Mammuthus primigenius (Blum.)	vertebra	fragment	d	shore and bar		C14
212	MKh - O 212	Mammuthus primigenius (Blum.)	vertebra	fragment	d	shore and bar		C14
213	MKh - O 213	Mammuthus primigenius (Blum.) (small)	astragalus		d	shore and bar		C14
214	MKh - O 214	Mammuthus primigenius (Blum.)	vertebra	fragment	d	shore and bar		Trashed
215	MKh - O 215	Mammalia gen ***)	rib	fragment	d	shore and bar		Trashed
216	MKh - O 216	Mammuthus primigenius (Blum.)	rib	fragment	d	shore and bar		C14
217	MKh - O 217	Mammuthus primigenius (Blum.)	limb bone	fragment	d	shore and bar		C14
218	MKh - O 218	Mammuthus primigenius (Blum.)	limb bone	fragment	d	shore and bar		GIN-9903
219	MKh - O 219	Mammuthus primigenius (Blum.)	rib	fragment	d	shore and bar		C14
220	MKh - O 220	Mammuthus primigenius (Blum.)	os tarsale IV-V	fragment	d	shore and bar		C14
221	MKh - O 221	Rangifer tarandus (L.)	humerus	fragment	d	shore and bar		Trashed
222	MKh - O 222	Ovibos sp.	cervical vertebra		d	shore and bar		
223	MKh - O 223	Lepus sp.	limb bone	fragment	d	shore and bar		
224	MKh - O 224	Lepus sp.	tibia	distal fragment	d	shore and bar		
225	MKh - O 225	Lepus sp.	tibia	distal fragment	d	shore and bar		
226	MKh - O 226	Lepus sp.	sacrum		d	shore and bar		
227	MKh - O 227	Rangifer tarandus (L.)	radius	proximal fragment	d	shore and bar		
228	MKh - O 228	Mammuthus primigenius (Blum.)	vertebra	fragment	d	shore and bar		Trashed
229	MKh - O 229	Mammalia gen. *****)	large limb bone	fragment	c	MKh main section, at the boundary of inserted alass		C14
230	MKh - O 230	Equus caballus L.	humerus	proximal fragment	e	Holocene shore		
231	MKh - O 231	Mammuthus primigenius (Blum.)	tooth M3 upper		e	Holocene shore		
232	MKh - O 232	Panthera spelaea (Gold.)	mandible branch dex.		e	Holocene shore		
233	MKh - O 233	Panthera spelaea (Gold.)	canine		e	Holocene shore		
234	MKh - O 234	Mammuthus primigenius (Blum.)	cervical vertebra		e	Holocene shore		C14
235	MKh - O 235	Bison priscus (Boj.)	atlas	fragment	e	Holocene shore		C14
236	MKh - O 236	Bison priscus (Boj.)	metacarpal bone (Mc III)	fragment	e	Holocene shore		
237	MKh - O 237	Bison priscus (Boj.) ?	metapodium	fragment	e	Holocene shore		
238	MKh - O 238	Equus caballus L.	calcaneus	juv.	e	Holocene shore		
239	MKh - O 239	Equus caballus L.	upper tooth	fragment	e	Holocene shore		
240	MKh - O 240	Equus caballus L.	phalanx I	fragment	e	Holocene shore		
241	MKh - O 241	Bison priscus (Boj.) ? (large)	metatarsal bone	proximal fragment	e	Holocene shore		

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
242	MKh - O 242	Martes sp.	mandible, no teeth	fragment	e	Holocene shore		
243	MKh - O 243	Mammuthus primigenius (Blum.)	tooth dP4 lower	fragment	e	Holocene shore		
244	MKh - O 244	Bison priscus (Boj.)	upper tooth		e	Holocene shore		
245	MKh - O 245	Equus caballus L.	phalanx I		e	Holocene shore		
246	MKh - O 246	Equus caballus L.	phalanx I		e	Holocene shore		
247	MKh - O 247	Mammuthus primigenius (Blum.)	os scaphoid	3 fragments	e	Holocene shore		C14
248	MKh - O 248	Bison priscus (Boj.)	phalanx I	fragment	e	Holocene shore		
249	MKh - O 249	Mammalia gen. *****)	femur	fragment (caput femori)	e	Holocene shore		Trashed
250	MKh - O 250	Delphinapterus leucas ? (White whale)	scapula	fragment	e	Holocene shore	? recent	
251	MKh - O 251	Rangifer tarandus (L.)	cervical vertebra		e	Holocene shore		
252	MKh - O 252	Rangifer tarandus (L.)	lumbar vertebra		e	Holocene shore		
253	MKh - O 253	Lepus sp.	femur	proximal fragment	e	Holocene shore		
254	MKh - O 254	Rangifer tarandus (L.)	humerus	fragment	e	Holocene shore		
255	MKh - O 255	Mammuthus primigenius (Blum.)	milk tooth replaced	fragment	e	Holocene shore		
256	MKh - O 256	Rangifer tarandus (L.)	tooth		e	Holocene shore		
257	MKh - O 257	Mammalia gen. *****)	tooth	fragment	e	Holocene shore		
258	MKh - O 258	Rangifer tarandus (L.)	tooth lower (M)		e	Holocene shore		
259	MKh - O 259	Equus caballus L.	upper tooth	fragment	e	Holocene shore		
260	MKh - O 260	Equus caballus L.	tooth	fragment	e	Holocene shore		
261	MKh - O 261	Rangifer tarandus (L.)	lower tooth		e	Holocene shore		
262	MKh - O 262	Equus caballus L.	lower tooth	fragment	e	Holocene shore		
263	MKh - O 263	Equus caballus L.	lower tooth (Ω2)		e	Holocene shore		
264	MKh - O 264	Ovibos sp. or Alces sp.	lower tooth	fragment	e	Holocene shore		
265	MKh - O 265	Mammuthus primigenius (Blum.)	tooth dP3	fragment	e	Holocene shore		
266	MKh - O 266	Mammuthus primigenius (Blum.)	milk tooth	fragment	e	Holocene shore		
267	MKh - O 267	Rangifer tarandus (L.)	upper premolar tooth		e	Holocene shore		
268	MKh - O 268	Equus caballus L.	tooth	fragment	e	Holocene shore		Trashed
269	MKh - O 269	Equus caballus L.	milk incisor		e	Holocene shore		
270	MKh - O 270	Mammuthus primigenius (Blum.)	metacarpal bone (metacarpale I)		c	MKh main section		
271	MKh - O 271	Bison priscus (Boj.) (very large)	radius		c	MKh main section		
272	MKh - O 272	Equus caballus L.	lower tooth	fragment	e	Holocene shore		Trashed
273	MKh - O 273	Rangifer tarandus (L.)	tooth		e	Holocene shore		
274	MKh - O 274	Rangifer tarandus (L.)	lower premolar tooth		e	Holocene shore		

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
275	MKh - O 275	Rangifer tarandus (L.) ?	tooth, unerupted		e	Holocene shore		
276	MKh - O 276	Lepus sp.	tooth		e	Holocene shore		
277	MKh - O 277	Bison priscus (Boj.) ?	pelvis	2 fragments	e	Holocene shore		Trashed
278	MKh - O 278	Rangifer tarandus (L.) ?	caudal vertebra	fragment	e	Holocene shore		
279	MKh - O 279	Mammalia gen. *****)	rib	fragment	e	Holocene shore		Trashed
280	MKh - O 280	Equus caballus L.	humerus	fragment	e	Holocene shore		
281	MKh - O 281	Mammalia gen. *****)	cranium	fragment	e	Holocene shore		Trashed
282	MKh - O 282	Mammalia gen. *****)	cranium	fragment	e	Holocene shore		
283	MKh - O 283	Rangifer tarandus (L.)	tibia	distal fragment	e	Holocene shore		
284	MKh - O 284	Rangifer tarandus (L.)	astragalus		e	Holocene shore		
285	MKh - O 285	Equus caballus L.	phalanx II	fragment	e	Holocene shore		
286	MKh - O 286	Equus caballus L.	carpal bone		e	Holocene shore		
287	MKh - O 287	Equus caballus L.	phalanx II	fragment, badly rounded	e	Holocene shore		Trashed
288	MKh - O 288	Equus caballus L.	side metatarsal bone (Mt II)		e	Holocene shore		
289	MKh - O 289	Bison priscus (Boj.)	calcaneus	fragment	e	Holocene shore		
290	MKh - O 290	Rangifer tarandus (L.)	vertebra ?		e	Holocene shore		
291	MKh - O 291	Mammalia gen ***)	cranium, ear region	fragment	e	Holocene shore		
292	MKh - O 292	Phocidae gen.***)	cranium, ear region	fragment	e	Holocene shore		
293	MKh - O 293	Rangifer tarandus (L.) ?	carpal or tarsal bone		e	Holocene shore		
294	MKh - O 294	Bison priscus (Boj.)	vertebra	fragment	f	Distant bar		Trashed
295	MKh - O 295	Mammuthus primigenius (Blum.)	tusk	fragment	f	Distant bar		C14
296	MKh - O 296	Bison priscus (Boj.)	phalanx I	fragment	f	Distant bar		
297	MKh - O 297	Rangifer tarandus (L.)	tibia	distal fragment	f	Distant bar		
298	MKh - O 298	Mammuthus primigenius (Blum.)	tusk	fragment	f	Distant bar		
299	MKh - O 299	Rangifer tarandus (L.)	humerus	distal fragment	f	Distant bar		
300	MKh - O 300	Mammalia gen. *****)	vertebra	fragment	f	Distant bar		Trashed
301	MKh - O 301	Rangifer tarandus (L.)	antler	fragment	x			
302	MKh - O 302	Rangifer tarandus (L.)	lumbar vertebra		e	Holocene shore		
303	MKh - O 303	Rangifer tarandus (L.)	tibia	distal fragment	e	Holocene shore		
304	MKh - O 304	Rangifer tarandus (L.)	carpal or tarsal bone		e	Holocene shore		
305	MKh - O 305	Equus caballus L.	calcaneus		e	Holocene shore section		AMS only

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
306	MKh - O 306	Mammuthus primigenius (Blum.)	milk tusk	fragment	a	in situ, MKh main section, sands, fluvial-proluvial deposits	Redeposited ? H=11.5 m	GIN-9898
307	MKh - O 307	Mammuthus primigenius (Blum.)	femur	fragment juv.	a	in situ, baydzharakh "Ya", Lutz the Porter	26 m	GIN-9887
308	MKh - O 308	Mammalia gen. *****)	rib		a	in situ, MKh main section, baydzharakh "Rebro"	17.3 m	AMS only
309	MKh - O 309	Mammalia gen. *****)	limb bone	fragment	d	Shore, beginning of the MKh main section near the snow-patch		Trashed
310	MKh - O 310	Bison priscus (Boj.)	phalanx I fore limb		f	Cape Mamont, shore		
311	MKh - O 311	Mammuthus primigenius (Blum.)	large limb bone	fragment	f	Cape Mamont		C14
312	MKh - O 312	Mammuthus primigenius (Blum.)	tooth M2	heavily worn	e	Holocene shore		
313	MKh - O 313	Mammuthus primigenius (Blum.)	tooth M3 upper sin.		e	Holocene shore		
314	MKh - O 314	Mammuthus primigenius (Blum.)	tooth M1 upper	heavily worn	e	Holocene shore		
315	MKh - O 315	Mammuthus primigenius (Blum.)	tooth M2 or M3 lower	fragment juv.	e	Holocene shore		
316	MKh - O 316	Mammuthus primigenius (Blum.)	tooth	fragment	e	Holocene shore		
317	MKh - O 317	Mammuthus primigenius (Blum.)	tooth M2 (?)	fragment	e	Holocene shore		
318	MKh - O 318	Mammuthus primigenius (Blum.)	milk tooth replaced		e	Holocene shore		
319	MKh - O 319	Bison priscus (Boj.)	upper tooth		e	Holocene shore		
320	MKh - O 320	Equus caballus L.	incisor	completely worn down	e	Holocene shore		
321	MKh - O 321	Bison priscus (Boj.)	upper tooth		e	Holocene shore		
322	MKh - O 322	Mammalia gen. *****)	rib		b	MKh main section, beneath baydzharakh "Rebro"	14-17 m	
323	MKh - O 323	Mammuthus primigenius (Blum.)	atlas		d	Shore, beginning of the MKh main section near a snow-patch		GIN-9900
324	MKh - O 324	Mammuthus primigenius (Blum.)	metatarsal bone (metatarsale III)		d	Shore, beginning of the MKh main section near the snow-patch		
325	MKh - O 325	Mammalia gen. *****)	rib	fragment	c	MKh main section, the left side of the lower exposure		Trashed
326	MKh - O 326	Mammuthus primigenius (Blum.)	tibia	fragment, juv. diaphysis	c	MKh main section		C14

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
327	MKh - O 327	Mammalia gen. *****)	rib	fragment	c	MKh main section		C14
328	MKh - O 328	Mammuthus primigenius (Blum.)	astragalus		c	MKh main section		C14
329	MKh - O 329	Mammuthus primigenius (Blum.)	femur	fragment juv.	b	MKh main section, bone field " L "	14-40 m	GIN-9882
330	MKh - O 330	Rangifer tarandus (L.)	antebrachium	proximal fragment	b	MKh main section, bone field " L "	14-40 m	
331	MKh - O 331	Rangifer tarandus (L.)	humerus	distal fragment	b	MKh main section, bone field " L "	14-40 m	
332	MKh - O 332	Equus caballus L.	radius	proximal fragment	b	MKh main section, bone field " L "	14-40 m	GIN-9879
333	MKh - O 333	Bison priscus (Boj.)	radius	proximal fragments (2 pieces)	b	MKh main section, bone field " L "	14-40 m	GIN-9872
334	MKh - O 334	Rangifer tarandus (L.)	ulna		b	MKh main section, bone field " L "	14-40 m	
335	MKh - O 335	Mammuthus primigenius (Blum.)	tusk	fragment	b	MKh main section, bone field " L "	14-40 m	C14
336	MKh - O 336	Mammuthus primigenius (Blum.)	tusk	fragment	b	MKh main section, bone field " L "	14-40 m	C14
337	MKh - O 337	Rangifer tarandus (L.)	metacarpal bone		b	MKh main section, bone field "R"	20-35 m	
338	MKh - O 338	Mammuthus primigenius (Blum.)	lower milk tooth	fragment	b	MKh main section, bone field "R"	20-35 m	
339	MKh - O 339	Mammuthus primigenius (Blum.)	os carpale IV-V	distal fragment	b	MKh main section, bone field "'R"	20-35 m	C14
340	MKh - O 340	Lepus sp.	scapula		b	MKh main section, bone field " L "	14-40 m	
341	MKh - O 341	Lepus sp.	femur		b	MKh main section, beneath baydzharakh "Doska"	13-17 m	
342	MKh - O 342	Equus caballus L.	scapula	fragment	b	MKh main section, bone field "Q"	13-40 m	
343	MKh - O 343	Equus caballus L.	humerus	distal fragment	b	MKh main section, bone field "Q"	13-40 m	GIN-9886
344	MKh - O 344	Equus caballus L.	antebrachium		b	MKh main section, bone field "Q"	13-40 m	

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
345	MKh - O 345	Bison priscus (Boj.)	tibia		b	MKh main section, bone field "Q"	13-40 m	GIN-9885
346	MKh - O 346	Rangifer tarandus (L.)	tibia		b	MKh main section, beneath the lower exposure (N 3)	9-10 (<14) m	GIN-9888
347	MKh - O 347	Rangifer tarandus (L.)	radius		b	MKh main section, bone field "Q"	13-40 m	
348	MKh - O 348	Rangifer tarandus (L.)	scapula		b	MKh main section, bone field "J"	10-22 m	
349	MKh - O 349	Equus caballus L.	tibia	distal fragment	b	MKh main section, bone field "J"	10-22 m	
350	MKh - O 350	Bison priscus (Boj.)	metacarpal bone		c	MKh main section		
351	MKh - O 351	Bovidae gen. ****)	phalanx I	juv.	c	MKh main section		
352	MKh - O 352	Alces sp.?	os naviculare		c	MKh main section		
353	MKh - O 353	Mammuthus primigenius (Blum.)	ulna	distal fragment	b	MKh main section, beneath the lower exposure	9-10 (<14) m	C14
354	MKh - O 354	Mammuthus primigenius (Blum.)	tusk	sample cut out	b	MKh main section, start of the cliff	15-22 m	C14
355	MKh - O 355	Mammuthus primigenius (Blum.)	tusk	sample cut out	b	MKh main section between baydzharakhs "Zayats" and "Zayats - 2"	15-16 m	GIN-9895
356	MKh - O 356	Lepus sp.	pelvis	fragment	b	MKh main section, beneath baydzharakh "Rebro"	14-17 m	
357	MKh - O 357	Equus caballus L. ?	incisor		b	MKh main section, bone field "Q"	13-40 m	
358	MKh - O 358	Mammuthus primigenius (Blum.)	pelvis	fragment juv.	b	MKh main section, beneath baydzharakh near the stairs	12-15 m	GIN-9896
359	MKh - O 359	Equus caballus L.	humerus		b	MKh main section, bone field " L "	14-40 m	GIN-9876
360	MKh - O 360	Equus caballus L.	radius		b	MKh main section, bone field " L "	14-40 m	GIN-9878

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
361	MKh - O 361	Rangifer tarandus (L.)	antler	fragment	b	MKh main section, bone field " L "	14-40 m	
362	MKh - O 362	Rangifer tarandus (L.) ?	cervical vertebra		b	MKh main section, bone field " L "	14-40 m	
363	MKh - O 363	Mammalia gen. *****)	rib		b	MKh main section, bone field " L "	14-40 m	Trashed
364	MKh - O 364	Equus caballus L.	phalanx I		b	MKh main section, beneath baydzharakh "Doska"	13-17 m	AMS only
365	MKh - O 365	Mammuthus primigenius (Blum.)	tusk	fragment	b	MKh main section, bone field " L "	14-40 m	Trashed
366	MKh - O 366	Rangifer tarandus (L.)	phalanx I		c	MKh main section		
367	MKh - O 367	Mammuthus primigenius (Blum.)	vertebra	fragment	c	MKh main section		
368	MKh - O 368	Lepus sp.	femur	distal fragment	c	MKh main section		
369	MKh - O 369	Rangifer tarandus (L.)	pelvis	fragment	c	MKh main section		
371	MKh - O 371	Mammuthus primigenius (Blum.)	tooth	fragment, cement plate	d	shore and bar		C14
372	MKh - O 372	Mammuthus primigenius (Blum.)	upper replaced tooth		d	shore and bar		
373	MKh - O 373	Equus caballus L.	humerus	distal fragment	d	shore and bar		
374	MKh - O 374	Equus caballus L.	phalanx III (hoof)		d	shore and bar		
375	MKh - O 375	Rodentia gen., Lepus sp.	small limb bones, teeth		d	shore, beneath lozhkoviye deposits, beneath snow-patch		
376	MKh - O 376	Equus caballus L.	mandible with M1-M3	fragment	d	shore and bar		
377	MKh - O 377	Rangifer tarandus (L.)	shed antler	fragment	d	shore and bar		
378	MKh - O 378	Rangifer tarandus (L.)	metatarsal bone	fragment	d	shore and bar		
379	MKh - O 379	Rangifer tarandus (L.)	metacarpal bone	distal fragment	d	shore and bar		
380	MKh - O 380	Mammuthus primigenius (Blum.)	tusk	sample cut out	b	MKh main section, bone field "J"	10-22 m	GIN-9890
381	MKh - O 381	Mammuthus primigenius (Blum.)	thoracic vertebra		b	MKh main section, beneath baydzharakh "Zayats"	12-15 m	C14
382	MKh - O 382	Mammuthus primigenius (Blum.)	vertebra	fragment	b	MKh main section, beneath baydzharakh "Zayats"	12-15 m	C14
383	MKh - O 383	Mammuthus primigenius (Blum.)	vertebra, spine	fragment	d	shore and bar		C14

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
384	MKh - O 384	Rangifer tarandus (L.)	shed antler	fragment	b	MKh main section, beneath baydzharakh "Rog"	18-24 m	GIN-9869
385	MKh - O 385	Mammalia gen. *****)	? mandible	fragment	c	MKh main section		
386.1	MKh - O 386a	Equus caballus L.	milk incisor		b	MKh main section, near "Kuno"	13 m (ca)	AMS only
386.2	MKh - O 386b	Rangifer tarandus (L.)	scapula		x			
387	MKh - O 387	Rangifer tarandus (L.) ?	femur	proximal fragment	b	MKh main section, beneath baydzharakh "Zayats"	12-15 m	AMS only
388	MKh - O 388	Mammuthus primigenius (Blum.)	ulna	proximal fragment	b	MKh main section, beneath the lower exposure	9-10 (<14) m	C14
389	MKh - O 389	Mammuthus primigenius (Blum.)	lower milk tooth	fragment	d	shore and bar		
390	MKh - O 390	Mammuthus primigenius (Blum.)	milk tooth	fragment	d	shore and bar		C14
391	MKh - O 391	Mammuthus primigenius (Blum.)	milk tooth	fragment	d	shore and bar		
392	MKh - O 392	Equus caballus L.	upper tooth (M3)		d	shore and bar		
393	MKh - O 393	Equus caballus L.	upper tooth (M1)		d	shore and bar		
394	MKh - O 394	Mammuthus primigenius (Blum.)	tooth	fragment	e	Holocene shore		C14
395	MKh - O 395	Equus caballus L.	phalanx III (hoof)		d	shore and bar		
396	MKh - O 396	Mammuthus primigenius (Blum.)	metacarpal bone (metacarpale I)		d	shore and bar		
397	MKh - O 397	Bison priscus (Boj.)	lower tooth		d	shore and bar		
398.1	MKh - O 398	Bison priscus (Boj.) ?	? os carpi radiale		d	shore and bar		
398.2	MKh - O 398	Rangifer tarandus (L.)	carpal bone (?)		d	shore and bar		
399	MKh - O 399	Equus caballus L.	radius	distal fragment, epiphysis, s/ad	d	shore and bar		
400	MKh - O 400	Mammuthus primigenius (Blum.)	tooth M3 upper	fragment	d	shore and bar		
401	MKh - O 401	Mammuthus primigenius (Blum.)	metacarpal bone (metacarpale I)		d	shore and bar		
402	MKh - O 402	Bison priscus (Boj.)	astragalus		d	shore and bar		
403	MKh - O 403	Bison priscus (Boj.)	metacarpal bone	fragment	d	shore and bar		
404	MKh - O 404	Bison priscus (Boj.) ?	metatarsal bone	distal fragment	d	shore and bar		
405	MKh - O 405	Mammuthus primigenius (Blum.)	thoracic vertebra	fragment	d	shore and bar		
405	MKh - O 405	Bison priscus (Boj.)	radius		d	shore and bar		

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
407	MKh - O 407	Bison priscus (Boj.) ?	rib	fragment	d	shore and bar		Trashed
408	MKh - O 408	Mammuthus primigenius (Blum.)	tusk	fragment	e	Holocene shore		C14
409	MKh - O 409	Mammuthus primigenius (Blum.)	tooth	fragment	e	Holocene shore		C14
410	MKh - O 410	Mammuthus primigenius (Blum.)	tusk	fragment	e	Holocene shore		C14
411	MKh - O 411	Bison priscus (Boj.)	phalanx II		e	Holocene shore		
412	MKh - O 412	Bison priscus (Boj.)	astragalus		e	Holocene shore		
413	MKh - O 413	Bison priscus (Boj.)	phalanx I fore limb		e	Holocene shore		
414	MKh - O 414	Equus caballus L.	astragalus		e	Holocene shore		
415	MKh - O 415	Bison priscus (Boj.)	phalanx II		e	Holocene shore		
416	MKh - O 416	Mammuthus primigenius (Blum.)	tooth lower replaced		e	Holocene shore		
417	MKh - O 417	Mammuthus primigenius (Blum.)	tusk	fragment	e	Holocene shore		C14
418	MKh - O 418	Equus caballus L.	metatarsal bone (Mt III)		e	Holocene shore		
419.1	MKh - O 419a	Bison priscus (Boj.) ?	phalanx	fragment	x			
419.2	MKh - O 419b	Bison priscus (Boj.)	mandible (ramus dex.) with P2-M3		e	Holocene shore		
420	MKh - O 420	Bison priscus (Boj.)	metacarpal bone		e	Holocene shore		
421	MKh - O 421	Mammuthus primigenius (Blum.)	tibia	proximal fragment	b	MKh main section, bone field "R"	20-35 m	GIN-9891
422	MKh - O 422	Mammuthus primigenius (Blum.)	scapula	fragment	b	MKh main section, bone field "R"	20-35 m	C14
424	MKh - O 424	Equus caballus L.	femur		b	MKh main section, bone field "R"	20-35 m	GIN-9873
425	MKh - O 425	Rangifer tarandus (L.)	femur	fragment juv. (shaft)	b	MKh main section, bone field "R"	20-35 m	
426	MKh - O 426	Mammuthus primigenius (Blum.)	rib	fragment	b	MKh main section, bone field "'R"	20-35 m	C14
427	MKh - O 427	Mammuthus primigenius (Blum.)	humerus	fragment	b	MKh main section, bone field "R"	20-35 m	GIN-9892
428	MKh - O 428	Mammuthus primigenius (Blum.)	scapula		c	MKh main section		C14
429	MKh - O 429	Mammuthus primigenius (Blum.)	pelvis	fragment	c	MKh main section		C14
430	MKh - O 430	Mammuthus primigenius (Blum.)	femur	distal fragment	c	MKh main section		C14
431	MKh - O 431	Mammuthus primigenius (Blum.)	pelvis	fragment	b	MKh main section, bone field "R"	20-35 m	GIN-9874
432	MKh - O 432	Mammuthus primigenius (Blum.)	pelvis	fragment	b	MKh main section, bone field "R"	20-35 m	GIN-9897

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
433	MKh - O 433	Mammuthus primigenius (Blum.)	ulna	proximal fragment	c	MKh main section		C14
434	MKh - O 434	Mammuthus primigenius (Blum.)	femur	fragment	c	MKh main section		C14
435	MKh - O 435	Mammuthus primigenius (Blum.)	pelvis	fragment	c	MKh main section		C14
436	MKh - O 436	Mammuthus primigenius (Blum.)	humerus	proximal fragment	d	shore and bar		GIN-9905
437	? MKh - O 437	Mammuthus primigenius (Blum.)	tibia	proximal fragment	c	MKh main section		C14
438	MKh - O 438	Mammuthus primigenius (Blum.)	rib		b	MKh main section, bone field "'R"	20-35 m	C14
439	MKh - O 439	Mammuthus primigenius (Blum.)	rib		b	MKh main section, bone field "R"	20-35 m	C14
440	MKh - O 440	Mammalia gen. *****)	rib	fragment	d	shore and bar		Trashed
441	MKh - O 441	Mammuthus primigenius (Blum.)	long limb bone	fragment	b	MKh main section, bone field "R"	20-35 m	C14
442	MKh - O 442	Mammuthus primigenius (Blum.)	femur		d	shore and bar		C14
444	MKh - O 444	Mammuthus primigenius (Blum.)	scapula		b	MKh main section, beneath baydzharakh "Zayats-2"	12-14 m	C14
445	MKh - O 445	Mammuthus primigenius (Blum.)	limb bone	fragment	b	MKh main section, bone field "'R"	20-35 m	C14
446	MKh - O 446	Mammuthus primigenius (Blum.)	pelvis	fragment	b	MKh main section, beneath baydzharakh "Zayats-2"	12-14 m	C14
447	MKh - O 447	Mammuthus primigenius (Blum.)	rib		b	MKh main section, beneath baydzharakh "Zayats-2"	12-14 m	C14
448	MKh - O 448	Mammuthus primigenius (Blum.)	patella		b	MKh main section, beneath baydzharakh "Zayats-2"	12-14 m	Trashed
449	MKh - O 449	Mammuthus primigenius (Blum.)	pelvis	fragment	b	MKh main section, beneath baydzharakh "Zayats-2"	12-14 m	Trashed
450	MKh - O 450	Mammuthus primigenius (Blum.)	metacarpal bone (metacarpale II)		b	MKh main section, beneath baydzharakh "Zayats - 2"	12-14 m	GIN-9881

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
451	MKh - O 451	Bison priscus (Boj.)	atlas		b	MKh main section, beneath baydzharakh "Zayats-2"	12-14 m	C14
452	MKh - O 452	Mammuthus primigenius (Blum.)	? femur	fragment juv.	b	MKh MKh main section, beneath baydzharakh "Zayats-2"	12-14 m	C14
453	MKh - O 453	Mammuthus primigenius (Blum.)	pelvis		b	MKh main section	24-39 m	GIN-9907
457	MKh - O 457	Mammalia gen. *****)	rib		d	shore and bar		Trashed
458	MKh - O 458	Mammuthus primigenius (Blum.)	rib		d	shore and bar		C14
462	MKh - O 462	Mammuthus primigenius (Blum.)	femur	distal fragment	c	MKh main section		C14
464	MKh - O 464	Mammuthus primigenius (Blum.)	tibia	fragment	e	Holocene shore		C14
465	MKh - O 465	Mammuthus primigenius (Blum.)	ulna	proximal fragment	e	Holocene shore		GIN-9906
466	MKh - O 466	Mammuthus primigenius (Blum.)	scapula	2 fragments	e	Holocene shore		GIN-9902
467	MKh - O 467	Mammuthus primigenius (Blum.)	tusk	fragment	e	Holocene shore		GIN-9904
468	MKh - O 468	Mammuthus primigenius (Blum.)	tibia	fragment	e	Holocene shore		
469	MKh - O 469	Mammuthus primigenius (Blum.)	tibia	fragment	e	Holocene shore		GIN-9884
470	MKh - O 470	Mammuthus primigenius (Blum.)	tibia	fragment juv.	e	Holocene shore		GIN-9901
471	MKh - O 471	Mammuthus primigenius (Blum.)	vertebra	fragment	e	Holocene shore		Trashed
472	MKh - O 472	Mammuthus primigenius (Blum.)	tusk	fragment	e	Holocene shore		C14
473	MKh - O 473	Mammuthus primigenius (Blum.)	pelvis	fragment	e	Holocene shore		C14
474	MKh - O 474	Bison priscus (Boj.)	rib		e	Holocene shore		C14
475	MKh - O 475	Bison priscus (Boj.)	rib		e	Holocene shore		C14
476	MKh - O 476	Bison priscus (Boj.)	rib		e	Holocene shore		C14
477	MKh - O 477	Mammuthus primigenius (Blum.)	tusk	fragment	e	Holocene shore		C14
478	MKh - O 478	Mammuthus primigenius (Blum.)	tusk	fragment	e	Holocene shore		C14
479	MKh - O 479	Bison priscus (Boj.)	atlas		e	Holocene shore		GIN-9894
480	MKh - O 480	Mammuthus primigenius (Blum.)	rib		d	shore and bar		C14
481	MKh - O 481	Mammuthus primigenius (Blum.)	thoracic vertebra	fragment	d	shore and bar		C14

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
482	MKh - O 482	Mammuthus primigenius (Blum.)	metatarsal bone (Mt II)	fragment	d	shore and bar		
483	MKh - O 483	Equus caballus L.	scapula		d	shore and bar		
484	MKh - O 484	Bison priscus (Boj.)	lumbar vertebra		d	shore and bar		
485	MKh - O 485	Equus caballus L.	phalanx III (hoof)		d	shore and bar		
486	MKh - O 486	Equus caballus L.	pelvis	fragment	d	shore and bar		
487	MKh - O 487	Mammuthus primigenius (Blum.)	tusk	fragment	d	shore and bar		C14
488	MKh - O 488	Mammuthus primigenius (Blum.)	vertebra, spine		d	shore and bar		C14
489	MKh - O 489	Bison priscus (Boj.)	phalanx II		d	shore and bar		
490	MKh - O 490	Equus caballus L.	tibia		d	shore and bar		
491	MKh - O 491	AVES: Cygnus bewickii (tundra swan)	humerus		d	shore and bar		
492	MKh - O 492	Bison priscus (Boj.)	metacarpal bone	fragment juv.	d	shore and bar		
493	MKh - O 493	Bison priscus (Boj.)	vertebra		d	shore and bar		
494	MKh - O 494	Mammuthus primigenius (Blum.)	? bone	fragment	d	shore and bar		Trashed
495	MKh - O 495	Mammalia gen. *****)	rib	fragment	d	shore and bar		Trashed
496	MKh - O 496	Equus caballus L.	radius	distal fragment	d	shore and bar		
497	MKh - O 497	Bison priscus (Boj.) ?	cranium	2 fragments	d	shore and bar		
498	MKh - O 498	Mammuthus primigenius (Blum.)	phalanx I (digit V)	proximal fragment	d	shore and bar		C14
499	MKh - O 499	Equus caballus L.	upper tooth	fragment	d	shore and bar		
500	MKh - O 500	Bison priscus (Boj.)	epistropheus (second cervical vertebra)		e	Holocene shore		GIN-9877
501	MKh - O 501	Lepus sp.	tibia	distal fragment	d	shore and bar		C14
502	MKh - O 502	Mammuthus primigenius (Blum.)	tusk	fragment	e	Holocene shore		C14
503	MKh - O 503	Equus caballus L.	thoraic vertebra	fragment	d	shore and bar		
504	MKh - O 504	Mammuthus primigenius (Blum.)	vertebra, spine		d	shore and bar		Trashed
505	MKh - O 505	Mammuthus primigenius (Blum.)	ulna	fragment	d	shore and bar		
506	MKh - O 506	Equus caballus L.	humerus	distal fragment	d	shore and bar		
507	MKh - O 507	Ovibos sp.	cervical vertebra		d	shore and bar		
508	MKh - O 508	Mammuthus primigenius (Blum.)	unidentifiable bone fragment	sampled for preservation	d	shore and bar		C14
509	MKh - O 509	Mammalia gen. *****)	unidentifiable bone fragment	fragment	d	shore and bar		Trashed
510	MKh - O 510	Rangifer tarandus (L.)	metacarpal bone	distal fragment	d	shore and bar		
511	MKh - O 511	Equus caballus L.	astragalus		d	shore and bar		
512	MKh - O 512	Mammuthus primigenius (Blum.)	rib	fragment	d	shore and bar		Trashed

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
513	MKh - O 513	Mammuthus primigenius (Blum.)	metacarpal bone (metacarpale III)		d	shore and bar		GIN-9908
514	MKh - O 514	Mammuthus primigenius (Blum.)	metacarpal bone (metacarpale I)		d	shore and bar		
515	MKh - O 515	Mammuthus primigenius (Blum.)	tooth M3 lower	fragment	c	MKh main section, closer part		
516	MKh - O 516	Equus caballus L.	tibia	distal fragment	d	shore and bar		
517	MKh - O 517	Mammuthus primigenius (Blum.)	carpal or tarsal bone		b	MKh main section, bone field "R"	20-35 m	Trashed
518	MKh - O 518	Mammuthus primigenius (Blum.)	carpal or tarsal bone		b	MKh main section, bone field "R"	20-35 m	Trashed
520	MKh - O 520	Rangifer tarandus (L.)	skull with antler	fragment	a	in situ, MKh main section, baydzharakh "Rog"	21.9 m	GIN-9875
521	MKh - O 521	Mammalia gen. *****)	long limb bone	fragment	a	in situ, MKh main section, baydzharakh ?"Krayniy"	17 m	AMS only
522	MKh - O 522	Mammuthus primigenius (Blum.)	mandible, symphysis, no teeth	fragment	f	Lake Mamont, shore		GIN-9893
523	MKh - O 523	Rangifer tarandus (L.) (large)	tibia	proximal fragment	a	in situ, MKh main section, baydzharakh	18 m.	AMS only
524	MKh - O 524	Rangifer tarandus (L.)	shed antler	fragment	f	Lake Mamont, shore		Trashed
525	MKh - O 525	Rangifer tarandus (L.)	antler	fragment	f	Lake Mamont, shore		Trashed
526	MKh - O 526	Rangifer tarandus (L.)	phalanx I		f	Lake Mamont, baydzharakh of the 1st level		
527	MKh - O 527	Mammuthus primigenius (Blum.)	tooth	fragment	f	Lake Mamont, shore		Trashed
528	MKh - O 528	Lepus sp.	radius	proximal fragment	f	Lake Mamont, baydzharakh of the 1st level		
529	MKh - O 529	Lepus sp.	radius		f	Lake Mamont, shore		
530	MKh - O 530	Mammalia gen. *****)	rib	fragment	a	MKh main section, beneath baydzharakh "Rebro"	17.3 m	Trashed
531	MKh - O 531	Rangifer tarandus (L.)	phalanx I		c	MKh main section		
532	MKh - O 532	Lepus sp.	ulna		b	MKh main section, near baydzharakh "Zayats"	12-15 m (ca)	

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
533	MKh - O 533	Mammuthus primigenius (Blum.)	limb bone	fragment	c	MKh main section		C14
534	MKh - O 534	Bison priscus (Boj.)	metatarsal bone	distal fragment	d	Shore, beyond the snow-patch		
535	MKh - O 535	Equus caballus L.	pelvis	fragment	d	Shore, beyond the snow-patch		
536	MKh - O 536	Equus caballus L.	humerus	distal fragment	d	Shore with rodents		
537	MKh - O 537	Bison priscus (Boj.) ?	metacarpal bone	proximal fragment	d	Shore with rodents		
538	MKh - O 538	Ovibos sp.	upper tooth (molar)		d	Shore with rodents		
539.1	MKh - O 539	Mammalia gen. *****)	skull	fragment	d	Shore with rodents		Trashed
539.2	MKh - O 539	Mammuthus primigenius (Blum.)	unidentifiable bone fragment	fragment	d	Shore with rodents, beneath lozhkoviye deposits		Trashed
540	MKh - O 540	Mammalia gen. *****)	skull	fragment	d	Shore with rodents		
541	MKh - O 541	Lepus sp.	humerus	distal fragment	d	Shore with rodents		
542	MKh - O 542	Carnivora gen.	mandible, no teeth	fragment	d	Shore with rodents		
543	MKh - O 543	Mammalia gen. *****)	long limb bone	fragment	a	in situ, MKh main section, baydzharakh ?"Krayniy"	17 m	AMS only
544	MKh - O 544	Mammalia gen. *****)	long limb bone	fragment	a	in situ, MKh main section, baydzharakh ?"Krayniy"	17 m	AMS only
545	MKh - O 545	AVES: Anser fabalis (goose)	humerus	proximal fragment	c	MKh main section		
546	MKh - O 546	Mammuthus primigenius (Blum.) ?	rib (caput)		x	?MKh main section, ?shore and bar		
547	MKh - O 547	Mammuthus primigenius (Blum.)	carpale III		b	MKh main section, bone field "R"	20-35 m	C14
548	MKh - O 548	Rangifer tarandus (L.)	epistropheus (second cervical vertebra)		d	shore and bar		
549	MKh - O 549	Mammuthus primigenius (Blum.)	carpale IV-V		b	MKh main section, bone field "R"	20-35 m	GIN-9880
550	MKh - O 550	Mammuthus primigenius (Blum.)	vertebra		b	MKh main section, bone field "R"	20-35 m	C14
551	MKh - O 551	Mammuthus primigenius (Blum.)	vertebra, spine		b	MKh main section, bone field "R"	20-35 m	C14
552	MKh - O 552	Mammuthus primigenius (Blum.)	vertebra, spine		b	MKh main section, bone field "R"	20-35 m	C14

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
553	MKh - O 553	Mammuthus primigenius (Blum.)	pelvis	fragment	b	MKh main section, bone field "R"	20-35 m	C14
554	MKh - O 554	Mammuthus primigenius (Blum.)	os scaphoid		b	MKh main section, bone field "R"	20-35 m	C14
555	MKh - O 555	Rangifer tarandus (L.)	scapula		c	MKh main section		
556	MKh - O 556	Rangifer tarandus (L.)	phalanx I		c	MKh main section		
557	MKh - O 557	Mammuthus primigenius (Blum.)	limb bone	fragment	d	shore and bar		Trashed
558	MKh - O 558	Mammuthus primigenius (Blum.)	pelvis	fragment	x			Trashed
559	MKh - O 559	Equus caballus L.	phalanx II		c	MKh main section		
560	MKh - O 560	Equus caballus L.	radius		d	shore and bar		
561	MKh - O 561	Equus caballus L.	astragalus		c	MKh main section		
562	MKh - O 562	Equus caballus L.	phalanx II		c	MKh main section		
563	MKh - O 563	Bison priscus (Boj.)	os sesamoid		c	MKh main section		
564	MKh - O 564	Equus caballus L.	femur		c	MKh main section		
565	MKh - O 565	Mammuthus primigenius (Blum.)	metapodium	fragment	c	MKh main section		Trashed
566	MKh - O 566	Mammuthus primigenius (Blum.)	metacarpal bone (metacarpale I)		c	MKh main section		
567	MKh - O 567	Mammuthus primigenius (Blum.)	tooth M1 (?) upper		e	Holocene shore		
568	MKh - O 568	Mammuthus primigenius (Blum.)	carpale III		e	Holocene shore		C14
569	MKh - O 569	Mammuthus primigenius (Blum.)	rib	fragment	d	shore and bar		C14
570	MKh - O 570	Mammalia gen. *****)	skull	fragment	e	Holocene shore		Trashed
571	MKh - O 571	Bison priscus (Boj.) ?	skull (basal)	fragment	e	Holocene shore		
572	MKh - O 572	Equus caballus L.	lower milk tooth		e	Holocene shore		
573	MKh - O 573	Rangifer tarandus (L.)	upper tooth		e	Holocene shore		
574	MKh - O 574	Equus caballus L.	metatarsal bone (Mt III)		e	Holocene shore		
575	MKh - O 575	Rangifer tarandus (L.)	calcaneus		e	Holocene shore		
576	MKh - O 576	Bison priscus (Boj.)	scapula	fragment	e	Holocene shore		
577	MKh - O 577	Rangifer tarandus (L.) ?	? metacarpal bone	proximal fragment	e	Holocene shore		Trashed
578	MKh - O 578	Equus caballus L.	metatarsal bone	distal fragment	e	Holocene shore		Trashed
579	MKh - O 579	Equus caballus L.	astragalus	fragment	e	Holocene shore		Trashed
580	MKh - O 580	Rangifer tarandus (L.)	antler	fragment	e	Holocene shore		Trashed
581	MKh - O 581	Bison priscus (Boj.)	metacarpal bone	fragment juv.	e	Holocene shore		
582	MKh - O 582	Equus caballus L. ?	humerus	distal fragment	e	Holocene shore		
583	MKh - O 583	Bison priscus (Boj.)	metacarpal bone	fragment	e	Holocene shore		
584	MKh - O 584	Mammuthus primigenius (Blum.)	rib	fragment (with vivianite)	e	Holocene shore		Trashed

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
585	MKh - O 585	Mammuthus primigenius (Blum.)	rib	fragment (with vivianite)	e	Holocene shore		Trashed
586	MKh - O 586	AVES: Gavia arctica (blackcraw diver)	humerus	fragment	e	Holocene shore		
587	MKh - O 587	Bison priscus (Boj.)	skull (intermaxillar bone)	fragment	e	Holocene shore		
588	MKh - O 588	Mammalia gen. *****)	rib	fragment	e	Holocene shore		C14
589	MKh - O 589	Mammuthus primigenius (Blum.)	rib	fragment	e	Holocene shore		Trashed
590	MKh - O 590	Equus caballus L.	tibia	distal fragment	e	Holocene shore		
591	MKh - O 591	Mammuthus primigenius (Blum.)	limb bone	fragment	e	Holocene shore		Trashed
592	MKh - O 592	Equus caballus L.	tibia	fragment	e	Holocene shore		
593	MKh - O 593	Mammuthus primigenius (Blum.)	limb bone	fragment	e	Holocene shore		C14
594	MKh - O 594	Bison priscus (Boj.)	radius	proximal fragment	e	Holocene shore		
595	MKh - O 595	Equus caballus L.	humerus		e	Holocene shore		GIN-9871
596	MKh - O 596	Mammuthus primigenius (Blum.)	os capri ulnare		e	Holocene shore		C14
597	MKh - O 597	Mammalia gen. *****)	skull	fragment	e	Holocene shore		
598	MKh - O 598	Mammuthus primigenius (Blum.)	phalanx (?)	fragment	e	Holocene shore		
599	MKh - O 599	Equus caballus L.	tibia	fragment	e	Holocene shore		
600	MKh - O 600	Equus caballus L. ?	tibia	fragment	e	Holocene shore		
601	MKh - O 601	Bison priscus (Boj.)	metatarsal bone	proximal fragment	e	Holocene shore		
602	MKh - O 602	Bison priscus (Boj.)	ulna	fragment	e	Holocene shore		
603	MKh - O 603	Equus caballus L.	scapula		e	Holocene shore		
604	MKh - O 604	Equus caballus L.	pelvis	fragment	e	Holocene shore		
605	MKh - O 605	Bison priscus (Boj.) ?	pelvis	fragment	e	Holocene shore		
606	MKh - O 606	Ovibos sp. ?	humerus	fragment	e	Holocene shore		
607	MKh - O 607	Equus caballus L.	pelvis	fragment	e	Holocene shore		
608	MKh - O 608	Bison priscus (Boj.)	humerus	distal fragment	e	Holocene shore		
609.1	MKh - O 609ÿ	Equus caballus L.	humerus	distal fragment	e	Holocene shore		
609.2	MKh - O 609Ÿ	Mammuthus primigenius (Blum.)	humerus	distal fragment	e	Holocene shore		
610	MKh - O 610	Bison priscus (Boj.)	thoracic vertebra		e	Holocene shore		
611	MKh - O 611	Delphinapterus leucas ? (White whale)	vertebra		e	Holocene shore	Recent	
612	MKh - O 612	Delphinapterus leucas ? (White whale)	vertebra		e	Holocene shore	Recent	
613	MKh - O 613	Delphinapterus leucas ? (White whale)	vertebra		e	Holocene shore	Recent	

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
614	MKh - O 614	Rangifer tarandus (L.)	lumbar vertebra		e	Holocene shore		
615	MKh - O 615	Rangifer tarandus (L.)	lumbar vertebra		e	Holocene shore		
616	MKh - O 616	Bison priscus (Boj.)	phalanx II	fragment	e	Holocene shore		
617	MKh - O 617	Equus caballus L.	metatarsal bone (Mt III)		f	Shore beyond the Cape Mamont		
618	MKh - O 618	Bison priscus (Boj.)	phalanx I (hind limb)		f	Shore beyond the Cape Mamont		
619	MKh - O 619	Mammuthus primigenius (Blum.)	skull	fragment	f	Lena Delta, Sobo-Sise Island		C14
620	MKh - O 620	Equus caballus L.	humerus	distal fragment	f	Lena Delta, Sobo-Sise Island		
621	MKh - O 621	Mammuthus primigenius (Blum.)	rib	fragment	f	Lena Delta, Sobo-Sise Island		C14
622	MKh - O 622	Mammuthus primigenius (Blum.)	rib	fragment (reddish-yellow color)	f	Lena Delta, Sobo-Sise Island		Trashed
623	MKh - O 623	Mammuthus primigenius (Blum.)	vertebra, spine		f	Lena Delta, Sobo-Sise Island		C14
624	MKh - O 624	Mammuthus primigenius (Blum.)	vertebra	fragment	f	Lena Delta, Sobo-Sise Island		C14
625	MKh - O 625	Lepus sp.	femur	fragment	b	MKh main section, beneath baydzharakh to the right from "Zayats"	12-15 m (ca)	AMS only
626	MKh - O 626	Lepus sp.	bone ?		b	MKh main section, beneath baydzharakh to the right from the stairs	11-13 m (ca)	AMS only
627	MKh - O 627	Lepus sp. ?	calcaneus		c	MKh main section		
628	MKh - O 628	AVES: Anas acuta (duck)	humerus	proximal fragment	c	MKh main section		
629	MKh - O 629	Lepus sp.	femur	fragment	c	MKh main section		
630	MKh - O 630	Rangifer tarandus (L.)	phalanx III (side hoof)		c	MKh main section		
631	MKh - O 631	Lepus sp.	tibia	proximal fragment	c	MKh main section		
633	MKh - O 633	Lepus sp.	tibia	proximal fragment	c	MKh main section		
634	MKh - O 634	Lepus sp.	pelvis	fragment	c	MKh main section		
635.1	MKh - O 635a	Lepus sp.	tibia	proximal fragment	d	shore and bar		
635.2	MKh - O 635b	Lepus sp.	pelvis	fragment	c	MKh main section		
636	MKh - O 636	Lepus sp.	scapula	fragment	d	shore and bar		

Table A5-5: continuation

1	2	3	4	5	6	7	8	9
637	MKh - O 637	Lepus sp.	tibia (2 pieces)		c	MKh main section		
638	MKh - O 638	Mammalia gen. *****)	os zygomaticum		c	MKh main section		
639	MKh - O 639	Lepus sp.	femur		f	Distant bar		
640	MKh - O 640	Rangifer tarandus (L.)	tooth		f	Distant bar		
641	MKh - O 641	Alopex sp. ?	vertebra		f	Distant bar		
642	MKh - O 642	Alopex sp. ?	vertebra (2 pieces)		f	Distant bar		
643	MKh - O 643	Mammalia gen ***)	skull	fragment	d	shore and bar		Trashed
644	MKh - O 644	Mammalia gen ***)	limb bone	small fragment	a	in situ, screened sample R4	18.4 m	
645	MKh - O 645	Lepus sp.	limb bone	fragment	a	in situ, screened sample R23, fluvial-proluvial deposits	Redep.? 11.5 m	
646	MKh - O 646	Lepus sp.	pelvis	fragment	c	MKh main section		

Table A5-6: List of screened samples for small fossils from the sediments of the Bykovsky Peninsula.

1. Mamontovy Khayata Ice Complex Outcrop			
B4	Stn. 590 m, Bdzh. with landmark 4.1	37.4 m	Sandy silt, grey, rich with plant detritus, with thin peat layers.
R1	Stn. 575-600 m, Bdzh. "Sv"	30.0 m	A layer of coarse sand with fine gravel, possibly of slope origin
B18	Stn. 760 m, Bdzh. above "Lu"	28.5 m	Silt, brownish-grey, peaty. Isolated rodent bones.
B3	Stn. 480 m, Bdzh.	26.0 m	Sand, grey, fine-grained, with thin rootlets and shrub twigs.
B17	Stn. 760 m, Bdzh. below "Lu"	22.5 m	Silt, grey, with peat lenses. Fragment of rodent tooth.
R3	Stn. 550 m, Bdzh. "Ro"	21.9 m	Silt, in which a fragment of reindeer antler was found (MKh-074)
R9	Stn. 500 m, Bdzh. D1	20.4 m	Sandy silt with a fragment of mammoth tusk (MKh-076)
R4	Stn. 615 m, Bdzh. G4	18.4 m	Silt with unidentifiable bone fragment
R10	Stn. 480 m, Bdzh. G1	18.4 m	A layer of coarse sand with fine gravel, possibly of slope origin
R11	Stn. 510 m, Bdzh. G2	18.4 m	Sandy silt with incomplete skeleton of hare (MKh-077)
R12	Stn. 525 m, Bdzh. D3	17.8 m	Sandy silt with a fragment of reindeer tibia (MKh-523)
R16	Stn. 850 m, Bdzh. "Re"	17.3 m	Soil horizon with a fragment of mammal rib (MKh-308)
B14	Stn. 825 m, Bdzh. "Do"	17.1 m	Silt, grey, with plant detritus.
R5'	Stn. 825 m, Bdzh. "Do"	17.1 m	Silt, rich with organic (peat), overlying a peat layer. Unidentifiable bone fragments (MKh-075)
R5	Stn. 825 m, Bdzh. "Do"	16.6 m	Silt, rich with organic (peat), underlying a peat layer. Isolated rodent teeth and bones.
R13	Stn. 525 m, Bdzh. G3	16.3 m	Peat, upper layer, with a fragment of hare tibia (MKh-633)
R18	Stn. 590 m, Bdzh.near G4	16.3 m	Silt
R15	Stn. 615 m, Bdzh. G4	15.6 m	Sandy silt with unidentifiable fragment of mammal limb bone
R2	Stn. 525 m, Bdzh. G3	15.5 m	Silt, in which a hare bone (femur) was found (MKh-080).
B15	Stn. 750 m, Bdzh.	15.0 m	Silt, grey, with peat layers.
R14	Stn. 750 m, Bdzh.	15.0 m	Sandy silt
B16	Stn. 710 m, Bdzh. Z1	14.7 m	Silt, brownish-grey, peaty.
B7	Stn. 290 m, Bdzh.	13.8 m	Silt, brownish-grey, with thin layers and lenses of peat.
B28	Stn. 540 m, Bdzh. "Ku"	12.5 m	Silt, grey, with plant detritus.
R8	Stn. 710 m, Bdzh. Z1	12.45 m	Silt underlying a peat layer.
B8	Stn. 340 m, Bdzh. B52	11.8 m	Silt, grey, aggregated, with abundant thin rootlets and shrub twigs.
B19	Southernmost outcrop (Stn.1400 + ca. 400 m)	1.0 m	Silt, grey, horizontally bedded, with plant detritus.
R17	Southernmost outcrop (Stn.1400 + ca. 400 m)	1.0 m	Silt with high ice content (14C samples taken from the same layer)
2. Fluvial-deluvial section in the southern part of the Mamontovy Khayata outcrop			
R20ÿ	Stn. 1400 m	14 m	Bedded sand.
R20Y	Stn. 1375 m	13.8 m	Bedded sand.
R20/	Stn. 1350 m	13.8 m	Bedded sand.
B27	Stn. 1425 m, 4 m from the top of the outcrop.		Silt, grey, with abundant thin rootlets.
R22	Stn. 1460 m		Bedded sand, ca. 0.5 m thick.
R23	Stn. 1450 m, 4.5-5 m from the top of the outcrop.		Sand with mammoth milk tusk.

Table A5-6: continuation

3. alas section south of the Camp (northern part of the Mamontovy Khayata Complex)			
B9	Stn. 180 m	5.0 m	Silt, grey, horizontally bedded, with peat layers and lenses
R7	Stn. 130 m	3.5 m	Sand, coarse-grained, same layer
R6	Stn. 160 m	3.2 m	Sand, coarse-grained
B11	Stn. 180 m	2.7 m	Sand, grey, coarse-grained, with gravel inclusions, silt and plant detritus beds. Isolated rodent teeth.
B29	Stn. 70 m	1.5 m	Sand, grey, fine-grained
4. alas section north of the Camp ("Distant Holocene")			
R21	"Distant Holocene" section	5 m	Sand with brownish-grey spotty coloration (probably, slope talus), 3 m thick
B20	"Distant Holocene" section	5.6 m	Sand, yellowish-grey, fine-grained, with the beds of plant detritus (dwarf birch leaves observed).
B21	"Distant Holocene" section	5.0 m	Plant detritus with the twigs of large shrubs.
B22	"Distant Holocene" section	4.7 m	Sand, yellow, medium-grained, with the beds of plant detritus; thin-wall shells of freshwater bivalves occur.
B23	"Distant Holocene" section	4.0 m	Silt, grey, sandy, with the lenses of dark-brown peat.
B24	"Distant Holocene" section	2.9 m	Silt, grey, sandy, with plant detritus.
B25	"Distant Holocene" section	1.5 m	Silt, grey, sandy.
B26	"Distant Holocene" section	0.2 m	Silt, grey, sandy.
5. Other localities			
B30	Mammoth Eye Lake		Modern sediment (surface sample)

Index "B" - samples screened with 0.5 mm mesh. Index "R" - samples screened with 1.0 mm mesh.
Abbreviations: Stn. - Station (in meters from the Camp). Bdzh. - baydzherakh.

EURASIAN ICE SHEETS:

Expedition to the lake Lyadhej-To (Polar Urals), July-August 1998

by Wolf-Dieter Hermichen and Frank Wischer

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EURASIAN ICE SHEETS:

Expedition to the lake Lyadhej-To (Polar Urals), July-August 1998

(Wolf-Dieter Hermichen and Frank Wischer)

Introduction

In order to establish a more reliable reconstruction of the glacial and climatic history of the Eurasian Arctic the project EURASIAN ICE SHEETS was initiated in 1997.

The project, funded by the European Science Foundation, is going to be run from 1998 until 2000, coordinated by John Inge Svendsen, University of Bergen, Norway.

6 groups from Norway, Finland, Sweden, Germany and Great Britain and their cooperative Russian scientific partners carry out extensive land-based fieldwork at geological key sites in different sectors of the Russian Arctic.

Within 'Working package 2: Southern flank of the Kara and Barents ice sheets' the scientific task of the AWI Potsdam is to contribute to the reconstruction of the late Pleistocene glacio-climatic history by investigating lake sediment sequences.

Reconnaissance expedition to the Lyadhej-To (Polar Urals) / Program

After a study of satellite images and air-photographs, the lake basin of Lyadhej-To (68°15'N, 65°45'E, 150 m a.s.l.) was recommended by Valery I. Astakhov, Institute for Remote Sensing Methods in Geology (VNIIKAM) St. Petersburg, to be a suitable sedimentary archive which is expected to accumulate continuously since last deglaciation.

The lake is situated at the NW-rim of the Polar Urals in a relatively fresh glacially formed Tundra landscape.

The lake basin is ca. 2,5 km long and 1,5 km wide, presumably carved into bedrock. The Lyadhej-To is surrounded by numerous smaller lakes.

Because until recently no ground-based information was available, a reconnaissance expedition in the frame of the Russian-Norwegian expedition PECHORA-98 was carried out to the lake and its surroundings.

This expedition should help to gain experience on the local situation and on the logistical possibilities and restrictions of Russian transport agencies and of the Geological Survey 'Polarnouralgeologiya', Vorkuta, as possible partners to a contract treaty in the planned 1999 coring field work.

The main scientific objectives of the fieldwork were the following:

1. to establish bathymetric maps of the Lyadhej-To and of some other unnamed smaller lakes in its surroundings;

2. hydrochemical studies on the water column (pH-, Eh-values, conductivity, oxygen content), sampling of water and of suspended load;

3. short coring of lake sediments by a gravity corer (length <60 cm);

4. geomorphological and glaciogeological reconnaissance of the surroundings of lake Lyadhej-To.

The search for suitable future lake sediment coring sites was carried out in cooperation with the 'Geomorphological group' (O. Maslenikova, VNIIKAM; M. Henriksen, Uni Bergen) who were collecting field evidence for the establishment of a geomorphological sketch map.

Course of the expedition:

July, 23, 1998:	Flight Berlin - St. Petersburg with full expedition equipment (250 kgs).
July, 24 - 25:	Preparation works in St. Petersburg, logistic support by agency VICAAR Ltd., St. Petersburg.
July, 26 - 28:	Transfer of equipment and people by train to Vorkuta.
July, 28 - 30:	Preparation works in Vorkuta.
July, 31:	Flight of the complete team of PECHORA-98 by Helicopter Mi-8 to the study area at lake Lyadhej-To (150 km, 1 hour) with a stopover on a endmoraine at 68°07'N, 65°43'E for a short local geomorphological survey.
July, 31 - August, 13:	Field work in the area Lyadhej-To.
August, 14 - 16:	Post-expedition work in Vorkuta.
August, 16-18:	Transfer of equipment and people by train from Vorkuta to St. Petersburg.
August, 19-21:	Post-expedition stay in St. Petersburg.
August, 22:	Flight St.Petersburg - Germany.

Sampling

Sampling of water and lake sediment cores was carried out from a rubber boat. The water depth was determined by sonar, navigation was performed by GPS.

Hydrochemical parameters (pH, Eh, conductivity, dissolved oxygen) were determined with an oxymeter and multifunctional water tester onboard.

For further laboratory investigations the water samples were splitted: One part was filtered (<45µm), the other one was poisoned by $HgCl_2$.

Short sediment coring (< 50cm) was done by a gravity corer using liners. After recovery the liners were sealed. On the camp site the samples were treated in two ways:

1) Immediate subsampling: The core was cut into subsamples of two centimetres length. The subsamples were stored in PE-containers, the uppermost subsamples (0-2cm) were poisoned with $HgCl_2$ to avoid biological activity.

2) Sealing for treatment at AWI: The uppermost (empty) part of the core tube was cut off before the tube was sealed.

Preliminary field results

The Lyadhej-To and the unnamed lake fro which core 1408 was taken are mesotrophpic to oligotrophic, even the bottom water is rich in oxygen, and pH is neutral to slightly basic. The unnamed lake with sampling site 1407 seems to be dystrophic.

The average conductivity of 58 µS/cm of the Lyadhej-To water is relatively low, the one of the two small unnamed lakes (PG 1408 and PG 1407) is even lower.

The thermal stratification of the Lyadhej-To indicates a metalimnion at depths between 7-8m to 13-14m.

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Table 1: Sampling sites & list of sediment cores/samples.

Sample name	core length (cm)	Water depth (cm)	Positon (N)	Position (E)	Remarks
PG1400-1	37,5	8,5	68°14'22"	65°46'35"	South-eastern shore-area of Lyadhej- To
PG1400-2	39	8,5	68°14'22"	65°46'35"	
PG1400-3	40,5	8,5	68°14'22"	65°46'35"	
PG1401-1	43	16	68°14'36"	65°47'15"	Ridge between the two lake basins
PG1402-1	42	24	68°14'25"	65°46'50"	Centre of the southern basin
PG1403-1	41	23	68°14'32"	65°47'02"	ca. 150m NE of PG 1402-1
PG1404-1	41	11	68°15'12"	65°47'47"	Local basin in northern part of Lyadhej-To
PG1405-1	40	21	68°15'04"	65°47'24"	Centre of the northern basin
PG1405-2	40	21	68°15'04"	65°47'24"	
PG1406-1	36	21	68°15'04"	65°47'24"	Water depth consists on a large area
PG1406-2	39	21	68°15'04"	65°47'24"	
PG1407-1	45	2	68°14'19"	65°46'13'	Small lake near the camp
PG1408-1	26	15,5	68°14'05"	65°45'39"	Small lake , ca. 600m SW' camp
PG1409-1 to9	–	-	68°14'12"	68°44'48"	Cliff at the bank of the river Malaya Lyadhejyakha, ca. 1,3km to the SW of the camp

Table 2: Results of hydrochemical in-situ studies (end of July 1998).

Sampling Site PG1402-1, Lyadhej-To, Southern basin					
z (m)	t (°C)	O_2 (mg/l)	PH	Eh (mV)	Conductivity (µS/cm)
0,1	16,3	9,6	7,8	276	62
5	16,4	8,8	8,0	228	68
10	12,9	8,8	7,9	231	49
15	10,3	9,1	7,5	249	57
20	10,2	10,5	7,5	253	57
24	9,2	10,0	7,6	238	58

Sampling Site PG1405-1/2, Lyadhej-To, Northern basin					
z (m)	t (°C)	O2 (mg/l)	pH	Eh (mV)	Conductivity (µS/cm)
0,1	16,2	9,4	8,3	216	55
10	13,9	8,0	7,9	212	59
15	10,0	8,1	7,5	212	56
20	9,6	8,5	7,5	223	55
21	9,8	7,8	7,7	197	56

Sampling Site PG1408-1					
z (m)	t (°C)	O2 (mg/l)	pH	Eh (mV)	Conductivity (µS/cm)
0,1	12,6	9,9	7,9	233	45
15	7,5	6,3	7,0	220	40

Sampling Site PG1407-1					
z (m)	t (°C)	O2 (mg/l)	pH	Eh (mV)	Conductivity (µS/cm)
0,1	11,1	9,1	7,3	266	21

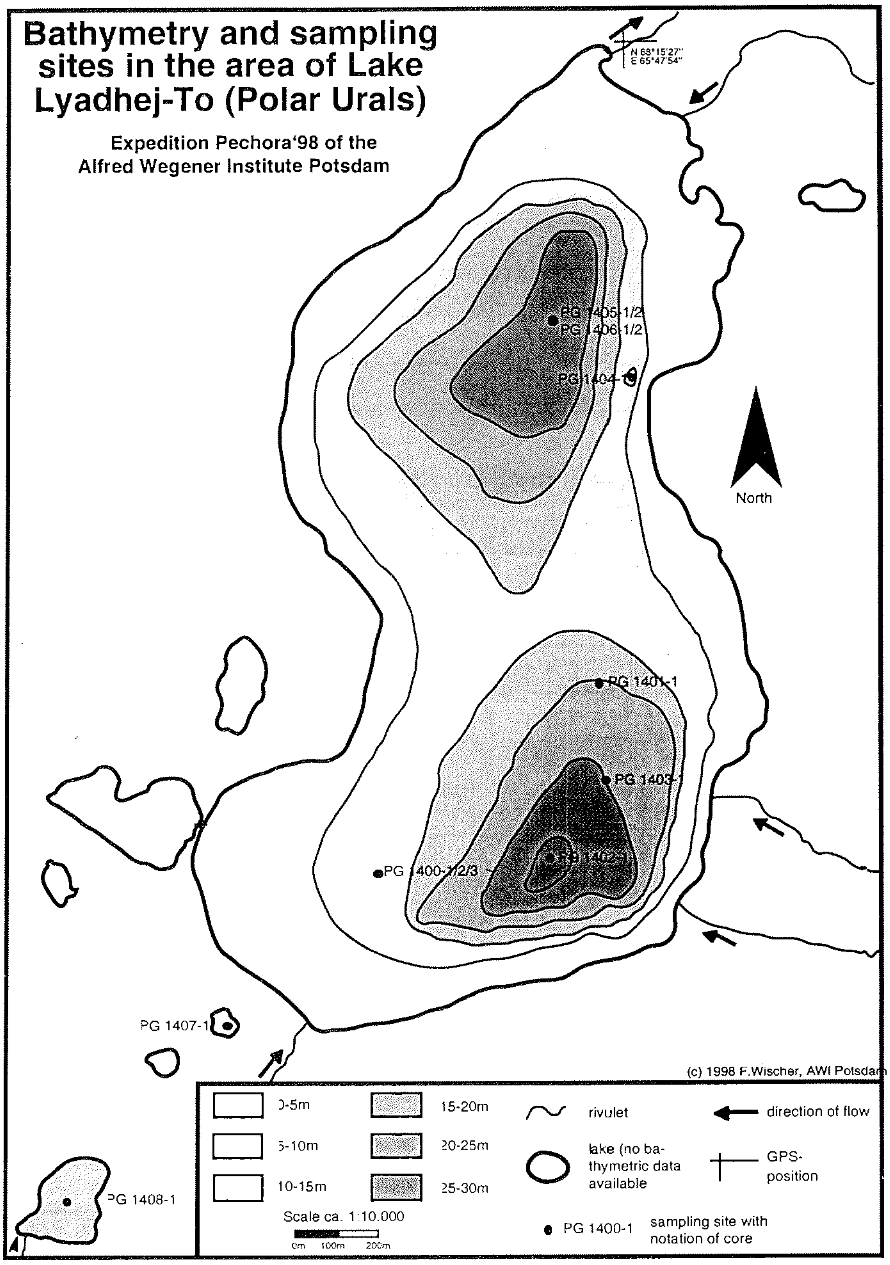

Figure 1: Bathymetry and sampling sites.

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