Russian-German Cooperation:
The Expedition
TAYMYR / SEVERNAYA ZEMLYA 1996

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with contributions of the participants

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RUSSIAN-GERMAN COOPERATION: THE EXPEDITION TAYMYR/SEVERNAYA ZEMLYA 1996

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Content

1 INTRODUCTION
(M. Melles, B. Hagedorn, D. Yu. Bolshiyanov)

1.1 Objectives

The field work on the Taymyr Peninsula and Severnaya Zemlya Archipelago in summer 1996 was carried out within the scope of the joint Russian-German research project "Taymyr", which had been established in 1993. Following a pilot phase, fundings were provided for the project in 1994 by the German Ministery of Education, Science and Technology (BMBF) and by the Russian Ministery of Science and Technical Policy. Financial support will be available until the end of 1997.

The project is carried out along a transect of ca. 1400 km length from the Northern Taiga in the surroundings of the town Norilsk, via different tundra zones on the Taymyr Peninsula, to the High-arctic Tundra on Severnaya Zemlya (Fig. 1-1). The main objective is a contribution to the understanding of the climatic and environmental history of northern Central Siberia during Late Quaternary time. Special emphasis is put on (1) the glacial history, (2) the relative influences of the West Siberian marine and East Siberian continental climates, (3) the position and extension of vegetation zones, and (4) the land-ocean-atmosphere interaction in dependence on the Late Quaternary climatic variations.

For these purposes, geomorphological and paleogeographical investigations are carried out and different natural data archives of the paleoenvironmental conditions are studied, including permafrost profiles, ground-ice bodies, and lake sediment sequences. The different archives gather individual information concerning the kind of paleoenvironmental evidence, and the length, completeness, and resolution of the documented time interval. The paleoenvironmental reconstructions, deduced from the composition of the natural data archives, are supported by investigations of seasonal dynamic processes taking place in the different climatic and environmental settings of the study area (Fig. 1-1). Research focuses on the water and sediment transport in the active layer, surface runoffs, and lake water column. Furthermore, biological and pedological processes, methane and carbon dioxide production in permafrost deposits and unfrozen lake sediments, and anthropogenic influences on the environment are studied. These investigations lead to a better understanding of the climatic and environmental influence on the archive formation and composition, and thus to a more substantiated interpretation of the proxy data from ancient deposits. Hence, from the multi-disciplinary geo-scientific research carried out in the project a comprehensive reconstruction of the Late Quaternary environmental history can be expected.

The expedition to the Taymyr Peninsula and Severnaya Zemlya Archipelago in 1996, reported here, was the forth within the scope of the project. The first field work, concentrating on lake sediment coring, was carried out on the lakes Lama, Pyassino, and Levinson-Lessing (Fig. 1-1) during a pilot expedition in summer 1993 (Melles et al. 1993, 1994). In summer 1994, comprehensive

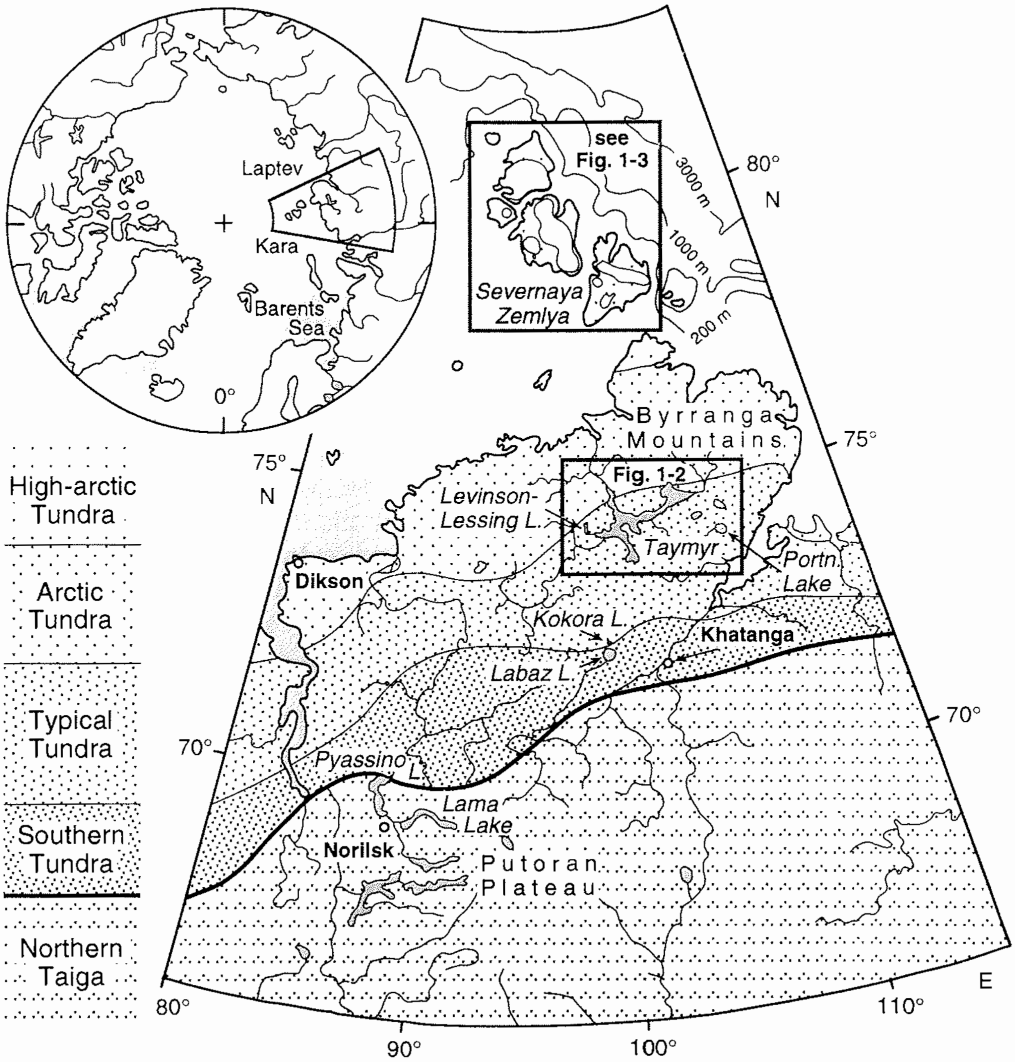


Figure 1-1: Map of the Taymyr Project study area with the present-day vegetation zones, geographic terms mentioned in the text, and the location of the more detailed maps in Figs. 1-2 and 1-3 (encircled).

geomorphological, geocryological, and recent process studies were carried out in the surroundings of the lakes Labaz and Levinson-Lessing (Siegert & Bolshiyanov 1995). These investigations were continued in spring to autumn 1995, and supplemented by deep sediment coring in the lakes Kokora, Levinson-Lessing, Taymyr, and Portnyagino, and by a reconnaissance expedition to Severnaya Zemlya (Bolshiyanov & Hubberten, 1996).

The sample and data sets for both the recent process studies and the paleoenvironmental reconstructions were widely completed during the expedition in 1996. Very promising material is now available from the entire transect crossing the study area from south to north (Fig. 1-1). For 1997, only a small expedition to the Norilsk area is planned, on which the large-scale sediment architecture in the lakes Lama and Pyassino shall be investigated by sub-bottom profiling surveys, and the available lake sediment records extended towards older, pre-Late Weichselian times.

1.2 Itinerary

The multi-disciplinary expedition to Central Siberia from June to Sept. 1996 was separated into two major parts: on the Taymyr Peninsula and on the Severnaya Zemlya Archipelago (Fig. 1-1). Both expedition parts were further subdivided with respect to the areas and the times of field work in dependence on individual objectives.

Most of the German field equipment for all these expedition parts was shipped from Bremerhaven to St. Petersburg in April 1996. After the end of the expedition, some delicate samples and equipment were delivered to Germany together with regular flights of some expedition members in Aug. 1996. Other samples were transported back to Germany in Oct. 1996 by participants on a workshop helt in St. Petersburg. Samples from the expedition part on Severnaya Zemlya were sent by the RV 'Akademic Federov' in Jan. 1997. The major part of the German field equipment was delivered to Bremerhaven by a forwarding agency in March 1997.

1.2.1 Taymyr Peninsula

On June 9, the 9 participants (5 German, 4 Russian) on the *first expedition part* to the Taymyr Peninsula took a charter flight from St. Petersburg to Khatanga (Fig. 1-1) together with most of the field equipment and the participants on the expedition to Severnaya Zemlya. From Khatanga, 3 helicopter (MI-8) races delivered the participants and most of the cargo on June 10 and 12 to the northern shore of the Levinson-Lessing Lake, where the major field camp for the expedition on the Taymyr Peninsula was set up (Fig. 1-2). This expedition part concentrated on investigations of water and sediment transport into the Levinson-Lessing Lake and active layer hydrology during the snow melt, on geomorphological research, and on biological studies.

During the *second expedition part*, from July 18 to Aug. 16, the field work at the Levinson-Lessing Lake was extended especially by pedological studies, investigations of Late Quaternary permafrost profiles, and sub-bottom profiling in lakes. For these purposes, the expedition was joined by 16 additional members. Three of them reached the Levinson-Lessing Lake by helicopter from Dikson (Fig. 1-1), coming from a previous expedition part on Severnaya Zemlya (see next Chapter). Additional 13 participants (6 German, 5 Russian, 2 Swedish) took a regular flight via Moscow to Khatanga, and a helicopter further to the Levinson-Lessing Lake.

With the same helicopter, 2 groups of 4 members each travelled on to different places on the Taymyr Peninsula. One group investigated Late Quaternary

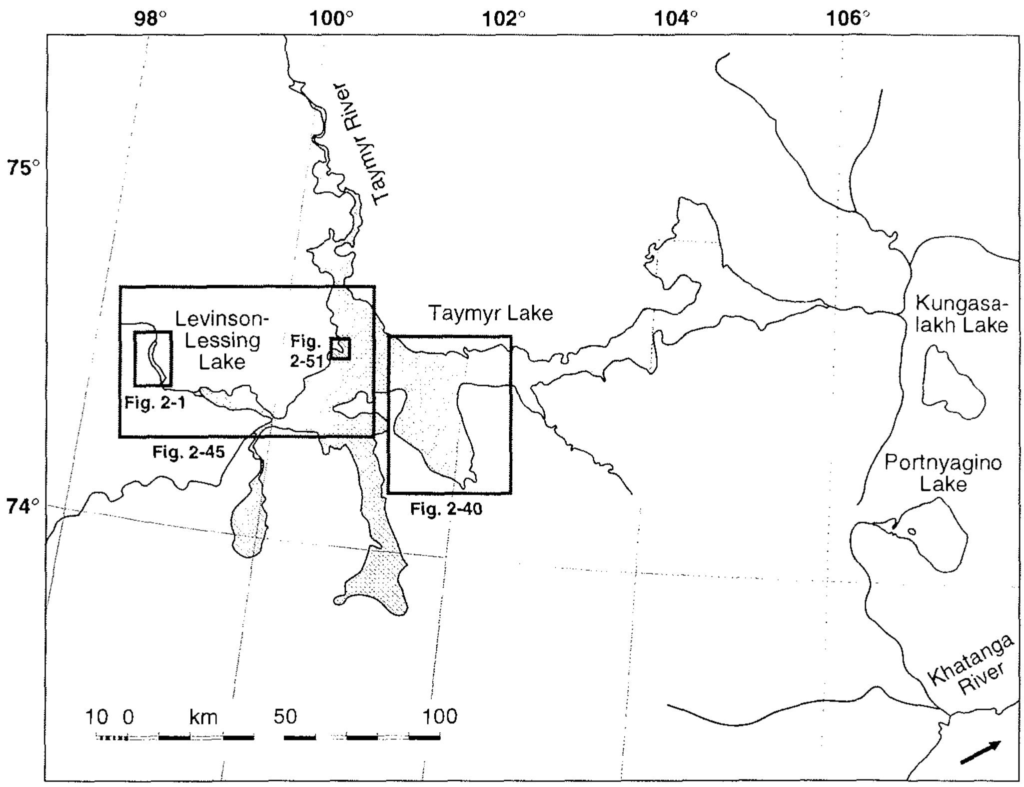


Figure 1-2: Map of the Taymyr Lake surroundings, northern Taymyr Peninsula, with geographic terms mentioned in the text and the locations of the more detailed maps in Figs. 2-1, 2-40 and 2-45 (encircled).

sediments exposed on Cape Sabler, at the western shore of Taymyr Lake (Fig. 1-2). This group subsequently made a reconnaissance tour along the Byrranga Mountains back to the Levinson-Lessing Lake. The other group carried out shallow seismic profiling on the central Taymyr Lake from a camp set up at the southern lake shore. On Aug. 8, this group was evacuated for additional profiling on the Levinson-Lessing Lake by helicopter, which was also used to deliver 5 expedition members from Levinson-Lessing Lake to Shell Lake.

On Aug. 15 and 16, most of the field equipment and 23 expedition members were delivered back to Khatanga by two helicopter races. The further travel to St. Petersburg was on Aug. 19 by charter flight. From St. Petersburg, the German expedition members took a regular flight to Berlin on Aug. 20, 1996.

The *third expedition part* was carried out from Aug. 16 to Sept. 5 by the 4 remaining participants in the vicinity of the camp at the northern shore of Levinson-Lessing Lake. The field work was strongly reduced; it concentrated on pedological studies until the end of the vegetation period. The expedition members and the little remaining equipment were delivered by a helicopter to Khatanga. The further travel back to Berlin or St. Petersburg was by regular flights via Moscow on Sept. 9, 1996.

1.2.2 Severnaya Zemlya Archipelago

In May 1996 the equipment for the field work on Severnaya Zemlya was transported with a special charter flight from St. Petersburg to Sredny Island to the west of Severnaya Zemlya (Fig. 1-3). This early date for the transport was necessary, because the only existing air strip on the archipelago closes with the beginning of melting in June until complete refreezing in November. At a later date in the year, therefore, the equipment could have been transported only by much more cost-effective helicopters. The expedition on the Severnaya Zemlya Archipelago was subdivided into two parts.

The *first expedition part* concentrated on lake sediment coring and recent process studies on October Revolution Island (Fig. 1-3). The four German and four Russian participants took part in a charter flight on June 9 from St. Petersburg to Khatanga (Fig. 1-1), which also delivered some of the scientists and most of the equipment for the expedition parts on the Taymyr Peninsula. The further travel to Severnaya Zemlya took place on June 19 by helicopter (MI-8). From Sredny Island, the helicopter on June 20 shifted all the equipment by two races to Changeable Lake (Fig. 1-3). While six expedition members built up the field camp and started with lake sediment sampling, two members drove a track (GTT) from Sredny via the sea ice to Changeable Lake, where they arrived on June 25.

On June 27 and June 30 the field camp was shifted by two races with the GTT from Changeable Lake to Fjord Lake (Fig. 1-3). The GTT was subsequently driven to the western shore of October Revolution Island, from where it was fetched to Sredny via the sea ice in autumn. The transport logistic used for the evacuation of the expedition was shared with Japanese scientists and a private agency. As a first step, the expedition was shifted from Changeable Lake to Sredny on July 11 and 12 by two helicopter races. Subsequently, all but one expedition member, who organized the transport of the samples and equipment to St. Petersburg, participated on a helicopter flight from Sredny to Dikson (Fig. 1-1) on July 15. From Dikson, three expedition members took a helicopter flight to Khatanga in order to join the running field work on the Taymyr Peninsula. The other expedition members participated on a charter flight to St. Petersburg on July 16, from where the German participants took a regular flight to Berlin on July 17.

The *second expedition part* on Severnaya Zemlya was carried out by two German and two Russian scientists from July 6 to July 25 on the northern Bolshevik Island. The German participants took regular flights to and from St. Petersburg. The transport and accomodation in between was organized by a private agency. Charter plains and helicopters were used for the travel between St.Petersburg and Dikson (Fig. 1-1), and between Dikson and Prima Station on Bolshevik Island (Fig. 1-3). Field work concentrated on pedological and biological studies. It was carried out in the vicinity of Prima Station (July 8 to 15 and July 19 to 22) and at a field camp at Bazovaia River (July 16 to 18), which was reached by Landcruiser.

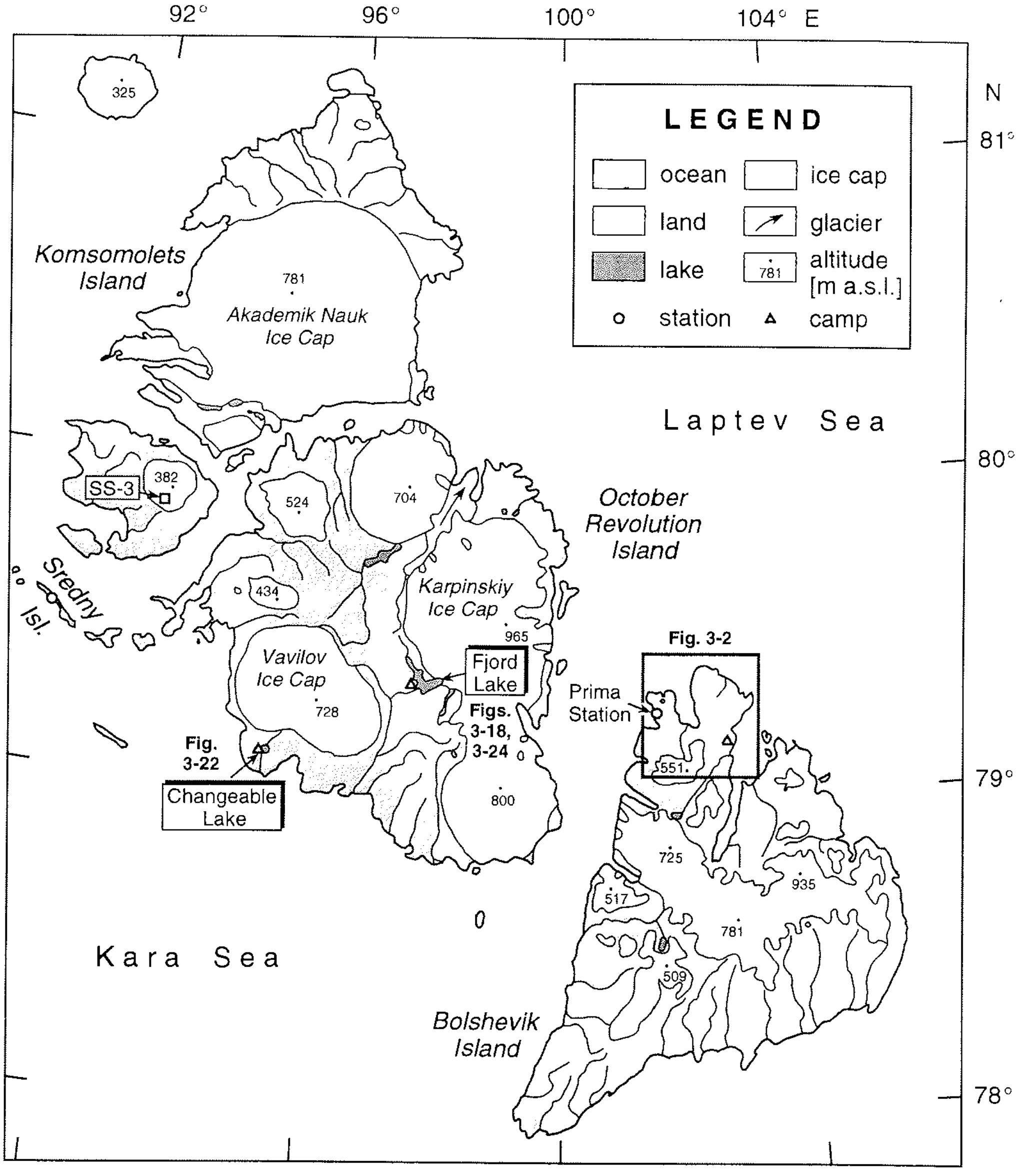


Figure 1-3: Map of the Severnaya Zemlya Archipelago showing the locations of Changeable Lake, Fjord Lake, Prima Station, and field camp to the east of Prima, where investigations were carried out during the expedition in summer 1996 (for more detailed maps see Figs. 3-2, 3-18, 3-22 and 3-24).

The transport of the equipment and of most samples from both expedition parts on Severnaya Zemlya was organized by the remaining member of the first expedition part. It took place by helicopter to Khatanga in Nov. 1996 and, together with some cargo from the expedition part on the Taymyr Peninsula, by charter flights via Norilsk to St. Petersburg in Dec. 1996. From St. Petersburg, the German samples were shipped to Bremerhaven by the RV ´Academic Federov´ until Jan. 2, 1997.

2 INVESTIGATIONS ON THE TAYMYR PENINSULA

2.1 Radioecological Studies
(I.O. Panasenkova)

During the period from June 18 to July 16, 1996, a radioecological program was carried out in the Levinson-Lessing Lake area (northern Taymyr Peninsula) in order to obtain information about natural and artificial radionuclide contents (NRN and ARN respectively) in different components of the natural environment. The research was a continuation of previous studies which had started in 1995. The following samples were taken (sample number in brackets; sample locations are shown in Figure 2-1):

- lake sediments (49),
- soils (34),
- lichens (5),
- mosses (2),
- higher vegetation (2),
- fish muscles and bones (7),
- reindeer muscles and bones (7),
- lemming bones (3).

In order to study the patterns of NRN and ARN concentrations in different lake environments, sediments of Levinson-Lessing Lake were sampled along a transect trending from the Krasnaya inflow in the north to the central lake basin (Fig. 2-1). In this way, samples were recovered both from different water depths (22 - 100 m) and in different distances from the main lake inflow. Sampling was carried out by gravity corers, which have a tube diameter of 6 cm. One core was recovered from 22, 52 and 60 m water depth, and 4 cores from 35, 75 and 100 m water depth. From each lake sediment sampling site, the uppermost 9-10 cm thick sediment horizon was taken for samples. For investigations of the temporal distribution of ARN and NRN in dependence on the different lake environments, gravity cores from the water depths 35, 75 and 100 m were divided into segments of 1 cm length and those from 22, 52 and 60 m water depth in segments of 3 cm. For comparizon, additional four cores were recovered from the nearest thermocarst lake at the northern shore of Levinson-Lessing Lake (54 cm water depth) and subsampled in a similar way into segments of 1 cm thickness (Fig. 2-1).

Soil samples were taken predominantly along two profiles in order to study the time-dependent re-distribution of radionuclides in the soil-vegetation cover (Fig. 2-1). The profiles trend from the northwestern and southeastern shore of Levinson-Lessing lake towards higher altitudes, respectively. They include several elements of the landscape, differing in surface slope, microrelief, vegetation pattern etc. To study vertical distribution of radionuclide contents in the soil, samples from the top layer of 10 cm were taken in intervals of 2 cm. Additional soil samples were taken in a typical polygonal tundra both from the centre and at the ridge of the polygon.

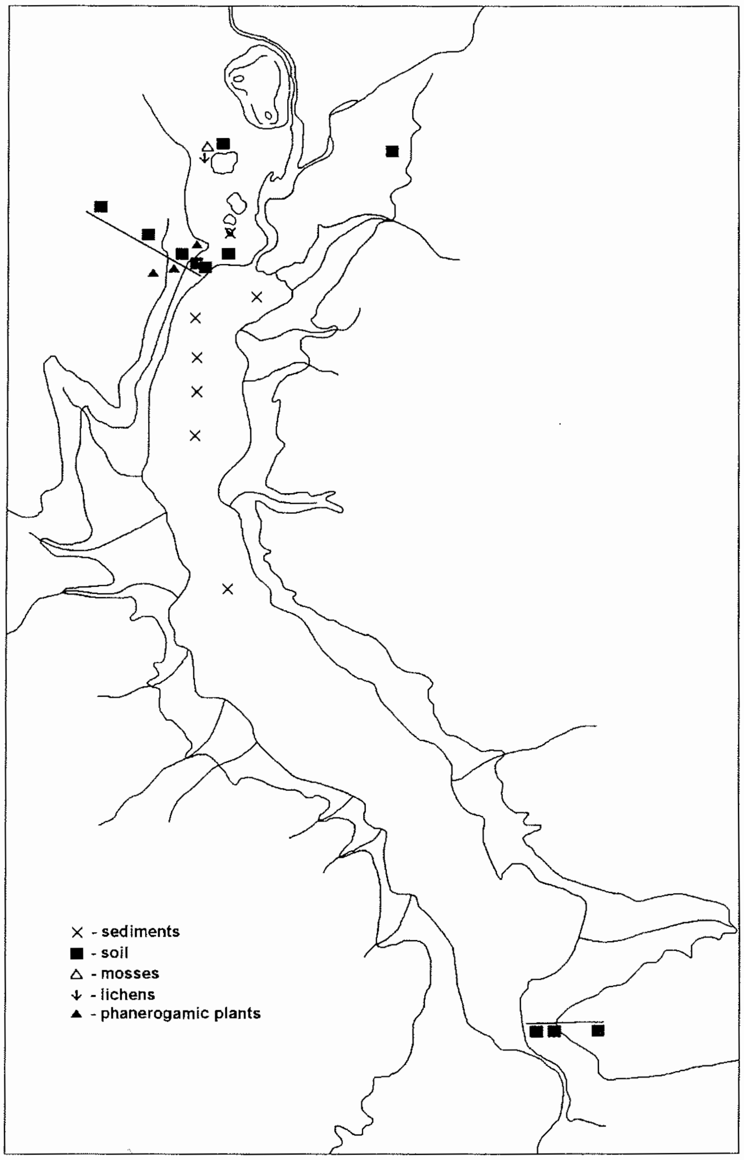


Figure 2-1: Map of Levinson-Lessing Lake showing sampling sites for radioecological measurements.

The lichen species chosen for radioecological studies (Cetrariella delisei, Cladina arbuscula, Flavocetraria cucullata) are feeded by reindeers. Samples were taken from the multi-grass mossy lichen shrubdwarf punctated tundras, from debris cones and mountain slopes, and in mossy lichen spotted tundras among stone deposits in nivation niche (Fig. 2-1). The considerable amount of samples taken should reveal the reasons for concentration variabilities in mossy and lichen tundra communities.

Finally, the already available sample set from osseous and muscle tissue of land animals (reindeer, siberian and ungulate lemmings) and of ichtiofauna was extended for measurements of contamination by ARN .

2.2 Pedological and Biological Studies

Permafrost affected soils in particular are supposed to be a considerable source and sink of greenhouse gases and as one of the largest cabon pools important for climate change processes. They are the linkage between terrestrial , limnic, and marine ecosystems and the atmosphere for climate and landscape changes. The focus of investigations over the last 3 years at Taymyr Peninsula and Severnaya Zemlya Archipelago within the scope of the project "The Environmental Development of Middle Siberia (Taymyr)" were permafrost affected soils as carbon sinks and sources.

Objectives of the 1996 expedition were to investigate the dynamics of soil organic matter, the primary production, and decomposition rates of different sites dependent on macro- and microrelief, to carry out investigations concerning the differentiation of the microrelief, and to determine the dynamics of gas production and emission (CO_2 and CH_4) by *in situ* measurements in connection with determination of microbial activity.

2.2.1 Mapping of Soils and Patterned Grounds

A prerequisite for all mentioned investigations and the basis of interpretation and the understanding of the landscape development is knowledge about the distribution of soil-plant complexes, patterned grounds and microrelief.

2.2.1.1 Soils
(A. Gundelwein, H. Becker, T. Müller-Lupp, N. Schmidt)

Materials and Methods. - Soil morphology was described according to the German soil survey manual (AG Boden, 1994). Main parameters are the thickness of diagnostic horizons and active layer, transition to the permafrost layers, soil colour (Munsell Soil Color Charts, 1993) and content of organic matter, moisture and proof of free reduced iron with $\alpha\alpha$-Dipyridyl, particle size distribution, bulk density, soil structure and texture, soil aggregation, content of stones, root restricting depth, parent material, as well as structure and decomposition of the organic material.

The soils were classified according to Soil Taxonomy, 6th edition (Soil Survey Stuff, 1994), the position of sites was appointed by GPS (Global Positioning System).

Soil mapping was carried out by dividing the region into typical landscape units, selected in dependence of vegetation, slope, water regime and parent material, and description of soils of these landscape units with a couple of sites in a wide, landscape-depending site-raster of 50-200 m.

Disturbed (for chemical analysis and isotope investigations) and undisturbed (for physical analysis and determination of important hydrological parameters such as bulk density, water binding capacity and permeability) soil samples were collected from typical soils, partly air dried and prepared for transportation. Important parameters such as acidity and water content were determined in the field.

Results. - As a result of the Taymyr-Expedition 1995, Pfeiffer et al. (1996) presented a first overview and a preliminary soil map of the Lake Levinson-Lessing region with a mapped area of 4 km^2 in total. The Lake Levinson-Lessing region was subdivided into eight different soil-plant-patterned ground-units, seven different soil types were described and sampled.

During the Taymyr-Expedition 1996, the soil survey at Lake Levinson-Lessing was completed and a total area of almost 22 km^2 was mapped (Fig. 2-2). The region of Levinson Lessing Lake is dominated by weak developed and wet soils. They are strongly influenced by cryoturbation and their position in the macro- and microrelief.

About a quarter of the investigated area is covered by ice-wedge Polygons with accumulation of weakly decomposed plant material and with wet soils of loamy-sandy sediments (sites 3, 7, 8, 9 and site 10: Histic Pergelic Cryaquepts; sites 23, 26 and 31: Pergelic Cryofibrists. Compare Fig. 2-2). The soils of these ice-wedge polygons can be found in the valley of Krasnaya River. They are comparable to the soils of the ice-wedge polygons at Lake Labaz in the lowland of the Taymyr Peninsula, south of the Byrranga Range (see Pfeiffer et al., 1996). They are covering an important part of the investigated area and are comparable with the soils at Lake Labaz in 1995.

Weakly developed soils were found at the slopes of the 300-500 m high mountains of the investigated area. Most of them are relatively dry soils with less or no profile differentiation (sites 5, 6, 20, 23, 25, 29 and site 33: Cryorthents, see Fig. 2-2). These soils cover an area of 8.8 km^2 in total. Other soils of the slopes are more wet, they show gleyic features and reduced iron (positive $\alpha\alpha$-Dipyridyl reaction. Sites 11, 13, 21 and site 34: Pergelic Cryaquepts). These soils cover about 18 % of the mapped area. Also, almost 18 % of the mapped area are bare ground with outcrops and gravel fields.

At the foot of the calcareous slope east of Krasnaya River colluvial material with high contents of soil organic matter (SOM, about 10-16 %) and neutral soil reaction was accumulated (site 16: Pergelic Cryoborolls). Colluvial material is accumulated in the upper part of the slope west of Krasnaya River as well as in the valley of Krasnaya River. The soil reaction is more acid (pH $CaCl_2$: 5.5) and it contains 7 % of SOM, less than the Pergelic Cryoboroll at site 16, east of Krasnaya River (site 12 and site 27: Pergelic Cryumbrepts). These soils are not wide-spread, they are strongly restricted to less than 2 % of the investigated area.

In contrast to the typical subarctic tundra of Lake Labaz with some well developed soils (differentiation into different soil and subsoil horizons, weathering and brownification, bleaching and illuviation) no indications for an advanced

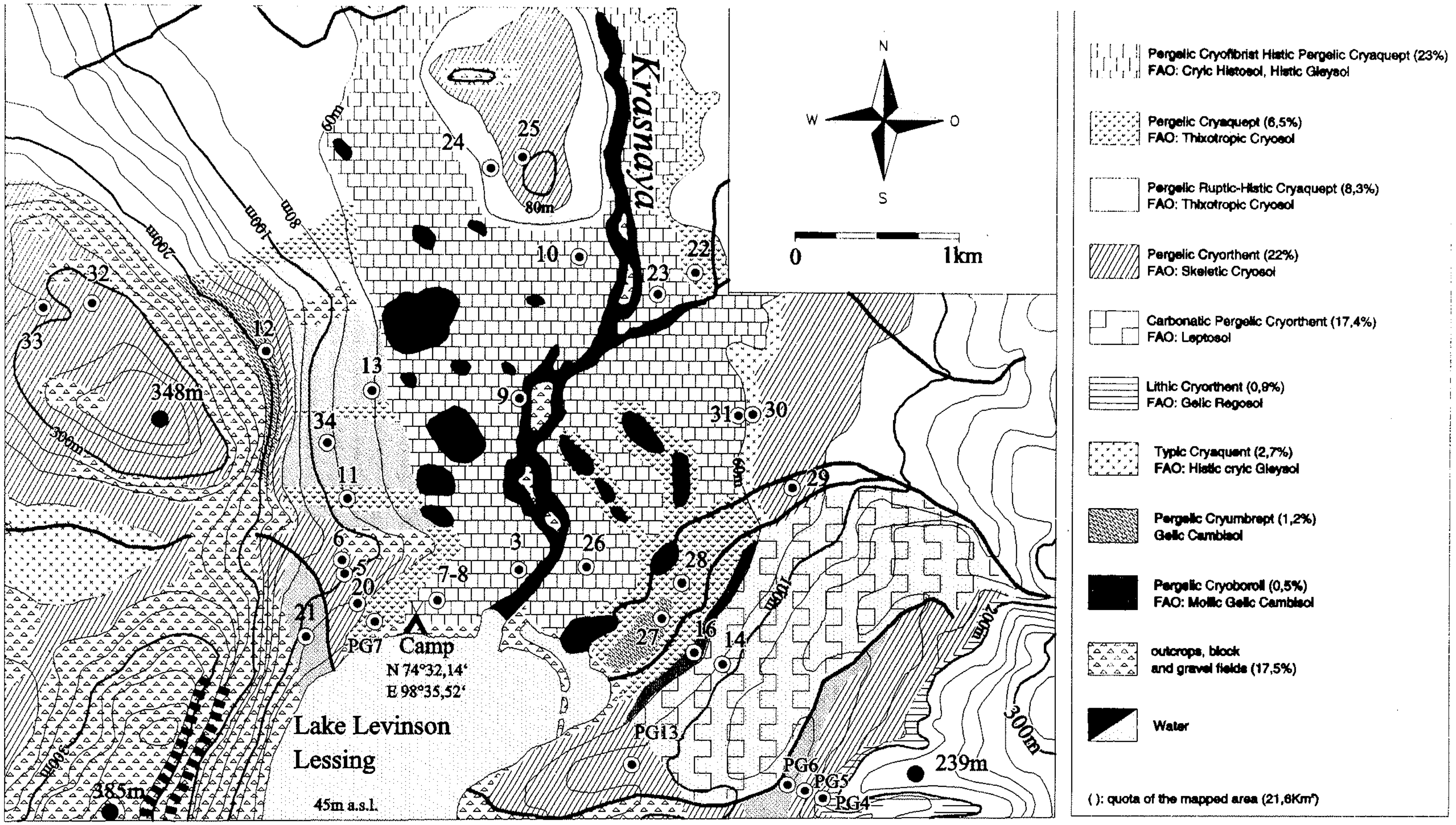


Figure 2-2: Distribution of soils in the northern surroundigs of Lake Levinson Lessing.

soil development were found at Levinson Lessing Lake. This could be caused by the colder climate of the Byrranga Range. The stronger erosion and solifluction at the steep slopes are typical for the sites at Levinson Lessing Lake.

2.2.1.2 Patterned Ground

(T. Mueller-Lupp, H. Becker)

The 1995 mapping of the patterned ground (see Pfeiffer et al., 1996) has been expanded and revised through field work in the summer 1996. The mapped area is now 38.8 km^2. The patterned grounds were classified according to Washburn (1979), which is purely descriptive and based on geometric shapes. The presence or absence of prominent sorting between stones and finer material is determined by the presence or absence of stone borders and the distribution of vegetation.

The basis for this mapping was a photocopy of topographical map (scale: 1 : 100 000). There was no map of this area available on a larger scale. In order to reduce the inaccuracies resulting from generalization, the map inlet has been sublemented through additional entries. These entries resulted in completion of the water distribution in the Krasnaya Valley. The mapping of the patterned ground and their distribution is shown in Figure 2-3.

The mapped area is divided into three categories of patterned grounds: sorted forms, nonsorted forms, and ice-wedge structures.

The <u>sorted forms</u> make up approximately 8 % of this area and are represented by stripes and nets. Sorted stripes are patterned ground with a striped pattern and a sorted appearance due to parallel lines of stones and interviening strips of finer material (Washburn, 1979, p.153). They are mostly oriented down the steepest avaible slope. Their appearance is limited exclusively to steep (30-40°) non-vegetated slopes of debris in areas higher than 160 m a.s.l.. It is important to note that a certain share of fine material is needed for the sorted stripes to develop and there was no permafrost found during excavation.

The netted structure of the sorted nets is made more pronounced by coarse material in the borders. The larger shapes, 1-2 m in diameter were found on nonvegetated plains upon the hill made of debris where as the smaler shapes, 20-30 cm in diameter were found in very wet, nonvegetated areas, for example under longlasting snowfields and along the lake shore. Similar to the sorted stripes , the larger forms were also excevated in areas where permafrost was not found. At the small forms the active layer extends to 20-30 cm depths. Sorted stripes are derived by downslope extension of sorted nets.

The <u>nonsorted forms</u> entail stripes, steps, circles and nets and form the largest area (41 %) of patterned ground. The nonsorted stripes are similar in shape to the sorted stripes, but have changing vegetated and nonvegetated strips. These nonsorted stripes are also called vegetated stripes. Upon closer examination a difference in the share of coarse material (<2 mm) between the vegetated and nonvegetated strips is regocnizable. Because this difference can only be determined through excavation, both kind of stripes are classified as nonsorted stripes. They are found in the transition zone between vegetated and nonvegetated areas.

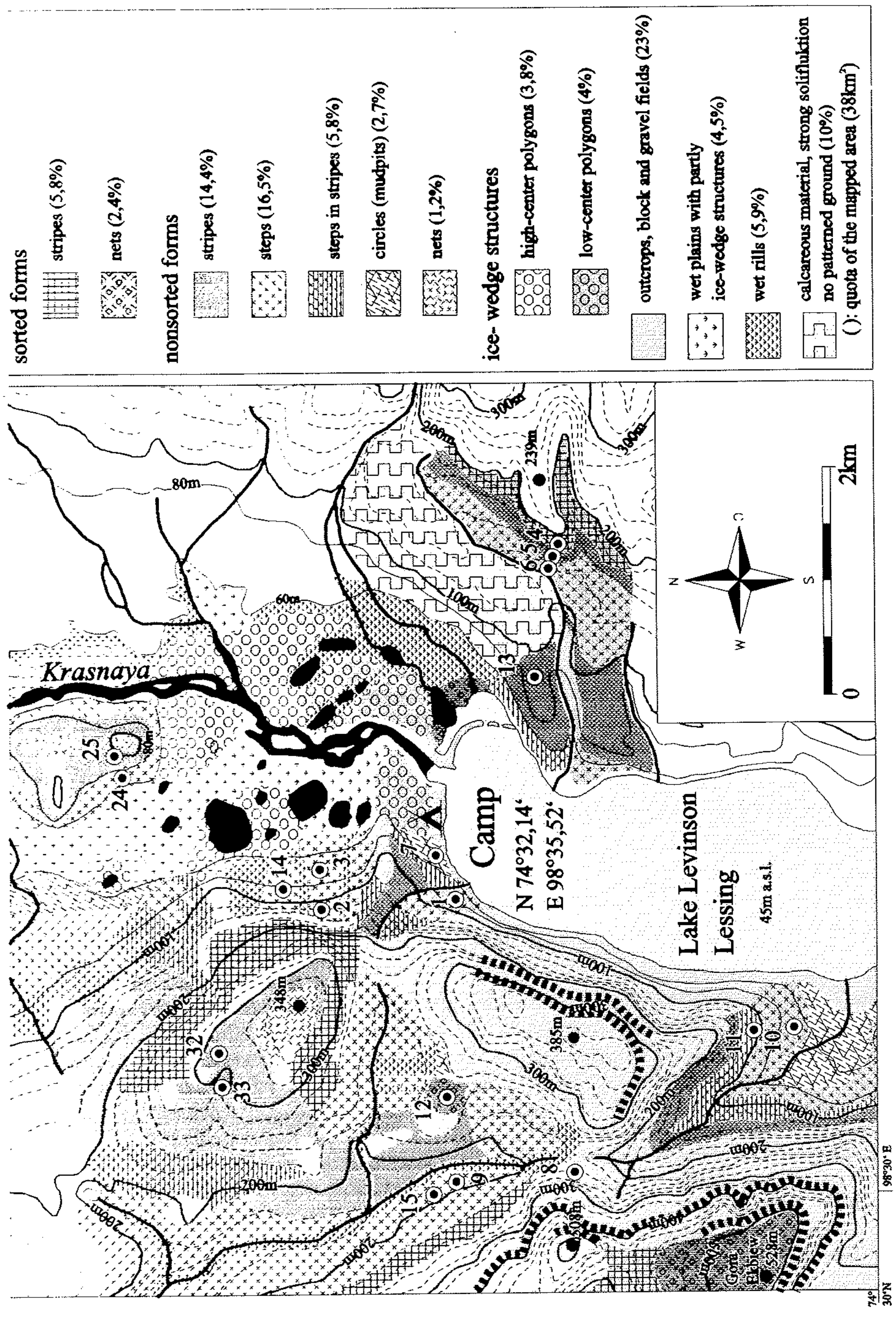


Figure 2-3: Distrubution of patterned ground, Lake Levinson Lessing

Nonsorted steps are the dominant patterned ground for the downer slopes. Steps are patterned ground with a step-like form and downslope border of vegetation encompassing an area of bare ground upslope. The bare ground is elipsoid with a diameter of 40-80 cm. The longer dimension of the steps extends in the direction of the steepest gradient. The share of coarse material compises less than 20 % by weight of the active layer.These soils are wet and saturated with water and therefore the solifluction plays an important role in forming the steps. There is often a burried organic horizont to be found at a depth of 25 cm on the lower border of the bare ground (see Fig. 2-4). The bare ground is often covered with a layer of fine and medium gravel.

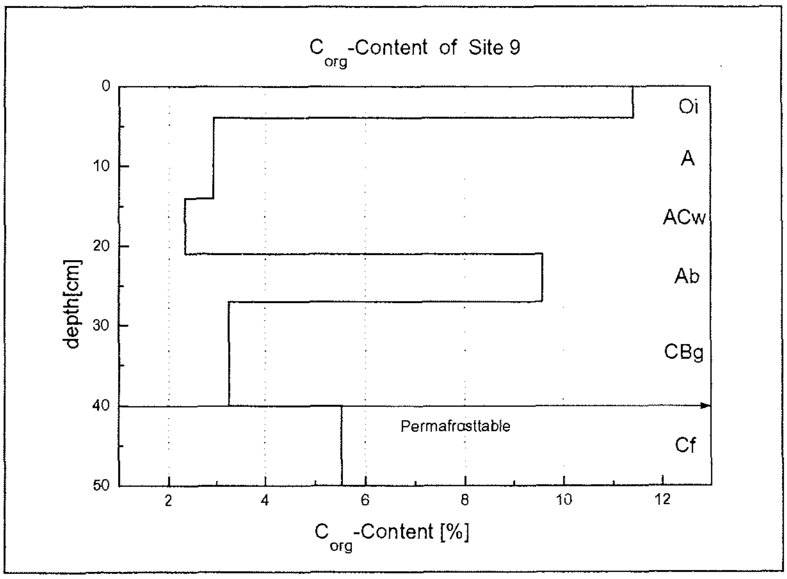


Figure 2-4: C_{org} content of site 9 (nonsorted step with burried organic horizon).

Mudpits or nonsorted circles are similar in appearance to the steps except for the fact that they seem to be on even ground below the slopes. Mudpits are patterned ground with a bare ground center and a surrounding vegetated border. The bare ground looks like a circle (Ø 60-120 cm). The border is mostly 4-8 cm higher than the center. The thickness of the active layer depends on presence or absence of vegetation.The active layer is 40 cm thick in the center, but under vegetation it is only 20 cm. Therefore, the permafrost table has an undulated appearance. Nonsorted nets can be found on the plain on top of mountains. The borders are vegetated with mosses, lichens and sometimes high vascular plants. The mesh is polygonal and has a diameter of 2-3 m.

The <u>ice-wedge structures</u> are unique for the Krasnaya valley. They are normally untypical for the Byrrangas but occur in the southern lowlands of Taymyr Peninsula, for example at Lake Labaz. In the Krasnaya valley both types are found: the high-center polygon and the low-center polygon (Fig. 2-5). High-and low-center polygons are rectangles or pentangons with site lengths about 10 to 12 m and both forms consist of peat. The ice-wedge is consistent with its borders. These borders can be raised or depressed. Low-center polygons have a raised border and a depressed center. During the summer the water-table in the centers is near the surface. Depressed borders are caused by thawing and give rise to high-center polygons if the thawing degrades ice-wedges enough to leave the center standing in relief (Washburn, 1979, p. 133). High-center polygons are degradation forms of low-center polygons.

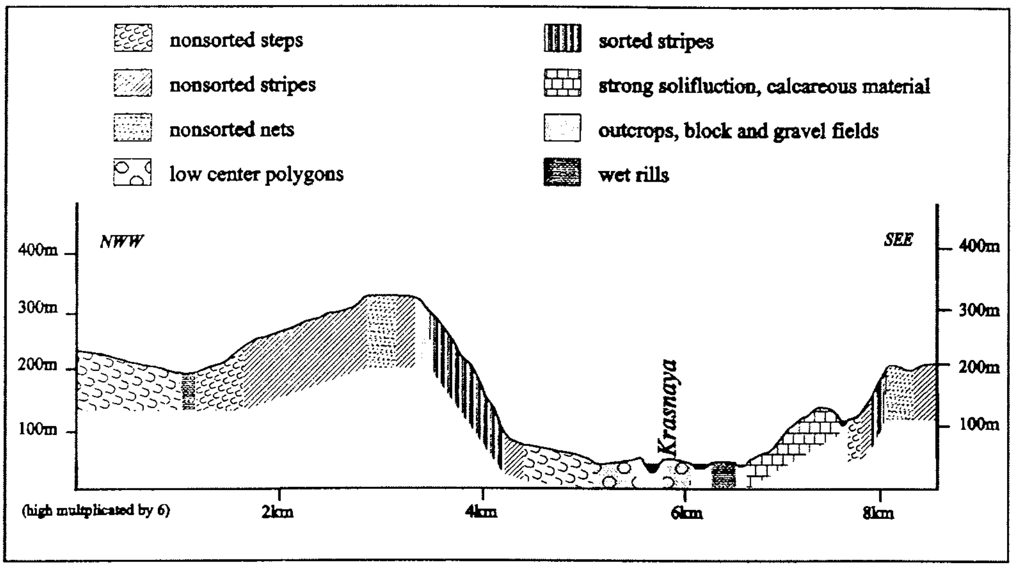


Figure 2-5: Distribution of patterned grounds in a cross-section through the Krasnaya valley from SEE to NWW.

Analyses. - 19 typical examples of patterned ground were excavated and samples were taken for more detailed investigations. 39 mixed samples were taken and are being examined for grain size, carbon content and iron extraction. Forty-five undisturbed samples were taken from typical profiles (see PG7, PG9 and PG14) and are being analyzed for distribution of pore size, porosity and density. Water content was measured gravimetrically on site with a Moisture Analyser (Sartorius MA30). The investigation of these parameters should establish differences between sorted and nonsorted areas, as well as between vegetated areas and none. These parameters are important for the progression of the frost and the related cryogenic processes of frostheaven and frostpressure.

Pyrophosphatic and Dithionitic iron oxides extraction serves as an additional parameter of soil developement. The degree of soil developement can be determined from the quotient of these two extractions. It is yet to be investigated if a difference in soil developement exists between bare ground and vegetated areas found in nonsorted steps and mudpits.

PG1 Pergelic Ruptic-Histic Cryaquept
nonsorted step

location:		Taimyr Peninsula, Lake Levinson Lessing, 74°32,22`N, 98°34,61`E
landscape:		slope (10°) west site Krasnaya river, 100m a.s.l.
vegetation:		*Dryas, Astragalus, Salix polaris, Salix reticula, Rumex v.*, mosses
permafrost-table:		22-42cm
parent material:		debris of permian slate clay and sandstone
hydrology:		wet
soil-profile:	1a:	ACw - Cg - Cf
	1b:	Oi - A - Cg - Cg
	1c:	Oi - A - ACw - Ab - Cg - Cf

Horizon		**depth [cm]**	**description**
1a	ACw	0-20	loam with 15% fine and medium gravel
	Cg	20-40	sandy loam with 50% medium and coarse gravel, weak pos. reaction of $\alpha\alpha$-Dipyridyl
	Cf	>44	
1b	Oi	0-3	partiallly decomposed plant material and root mat
	A	3-15	silt loam with 15% fine gravel,
	Cg	15-22	sandy loam with 50% medium and coarse gravel, weak pos. reaction of $\alpha\alpha$-Dipyridyl
	Cf	>22	
1c	Oi	0-10	partiallly decomposed plant material and root mat
	A	10-20	silt loam with 15% fine gravel
	ACw	20-27	loam with 15% fine and medium gravel
	Ab	27-33	loam with 25% fine and medium gravel
	Cg	33-42	sandy loam with 50% medium and coarse gravel, weak pos. reaction of $\alpha\alpha$-Dipyridyl
	Cf	>42	

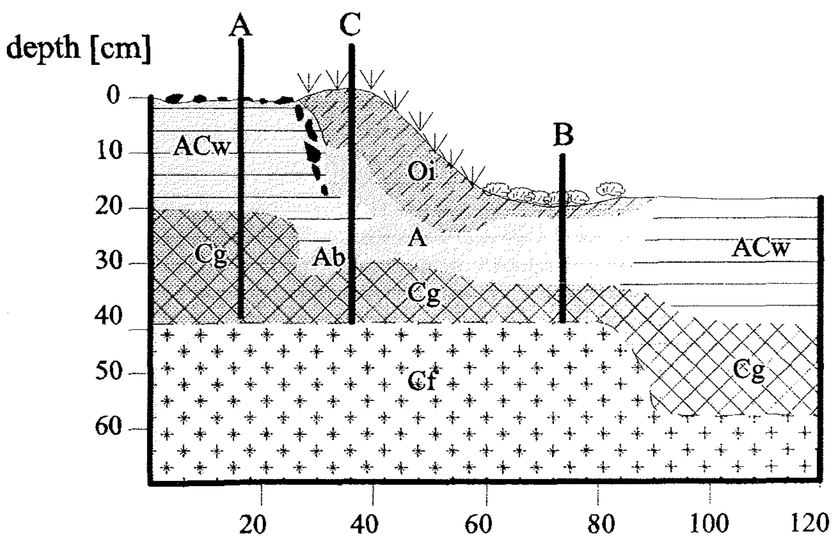


Figure 2-6: Soil profile site PG1, nonsorted steps.

PG4 Lithic Cryorthent
sorted stripes

location:	Taimyr Peninsula, Lake Levinson Lessing, 74°31,58'N, 98°40,59'E
landscape:	steep slope (45°) beyond the carbonatic slope, 160m a.s.l.
vegetation:	occasionally *Novosivirsia glacialis*
permafrost-table:	none
parent material:	debris of permian slate clay and sandstone
hydrology:	very dry

soil-profile: 4a: A - Cw - C
4b: C1 - C2

Horizont	depth [cm]	description
4a A	0-3	sandy loam 50% medium and coarse gravel
Cw	3-24	sandy loam with 50% coarse gravel and stones
C	>24	>75% stones
4b C1	0-24	sandy loam with 80% coarse gravel and stones
C2	>24	>75% stones

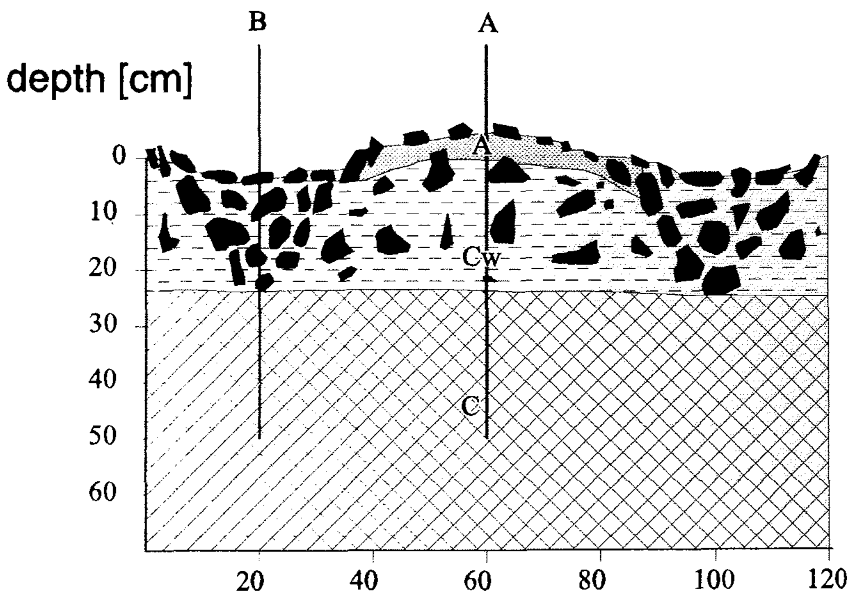


Figure 2-7: Soil profile PG4, sorted stripes.

PG5 Pergelic Cryorthent
nonsorted stripes

location:	Taimyr Peninsula, Lake Levinson Lessing 74°31,58'N, 98°40,56'E
landscape:	steep slope (40°) beyond the carbonatic slope , 130m a.s.l.
vegetation:	dryas on the vegetated stripes, occasionally *Novosivirsia glacialis*
permafrost-table:	33-54cm
parent material:	debris of permian slate clay and sandstone
hydrology:	dry
soil-profile:	5a: Oi - A - C - Cf 5b: Cw - C - Cf

Horizont	depth [cm]	description
5a Oi	0-4	partially decomposed dryas and roots
A	4-19	loam with 40% medium and coarse gravel
C	19-33	>75% coarse gravel and stones
Cf	>33	
5b Cw	0-27	sandy loam with >75% stones
C	27-54	>75% coarse gravel and stones
Cf	>54	

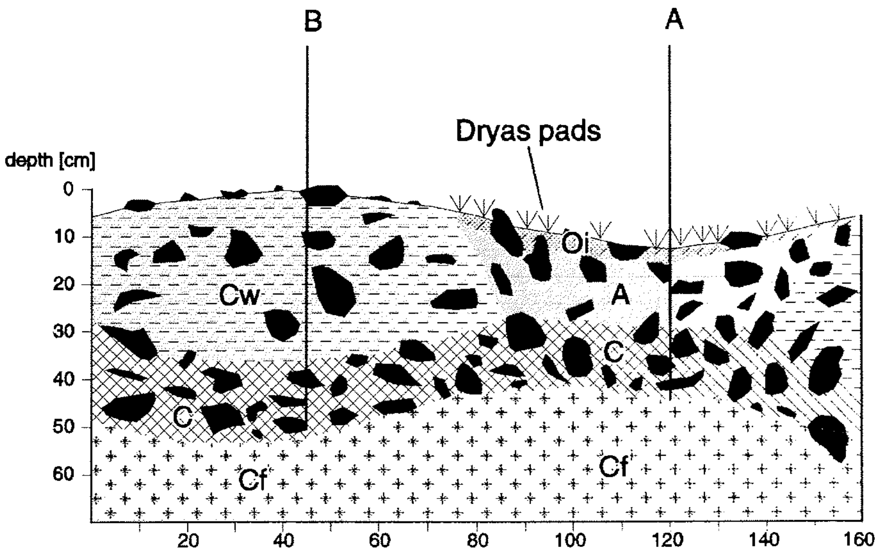


Figure 2-8: Soil profile PG5, nonsorted stripes.

PG9 Pergelic Ruptic-Histic Cryaquept
nonsorted steps

location: Taimyr Peninsula, Lake Levinson Lessing, 74°31,93`N, 98°29,55`E
landscape: wet slope 7° near little river in the high valley, 190m a.s.l.
vegetation: in the center no vegetation, in the trough mosses, dryas on the vegetated borders
permafrost-table: 40cm
parent material: debris of perm slate clay and sandstone
hydrologie: wet
soil-profile: 9a: ACw - CBg - Cf
9b: Oi - A - ACw - Ab - CBg - Cf

Horizont		depth [cm]	description
9a	ACw	0-28	silty clay loam with 20% fine and medium gravel, medium and coarse gravel at the surface
	CBg	28-40	silt loam with 15% medium and coarse gravel, pos. reaction of ((-Dipyridyl
	Cf	>40	
9b	Oi	0-5	slightly decomposed dryas andmosses
	A	5-14	loam with 20% fine and medium gravel,
	ACw	14-21	silty clay loam with 20% fine and medium gravel
	Ab	21-28	silty clay loam
	CBg	28-40	silt loam with 15 % medium and coarse gravel, pos. reaction of ((-Dipyridyl
	Cf	>40	silt loam with 55% (by weight) ice-content

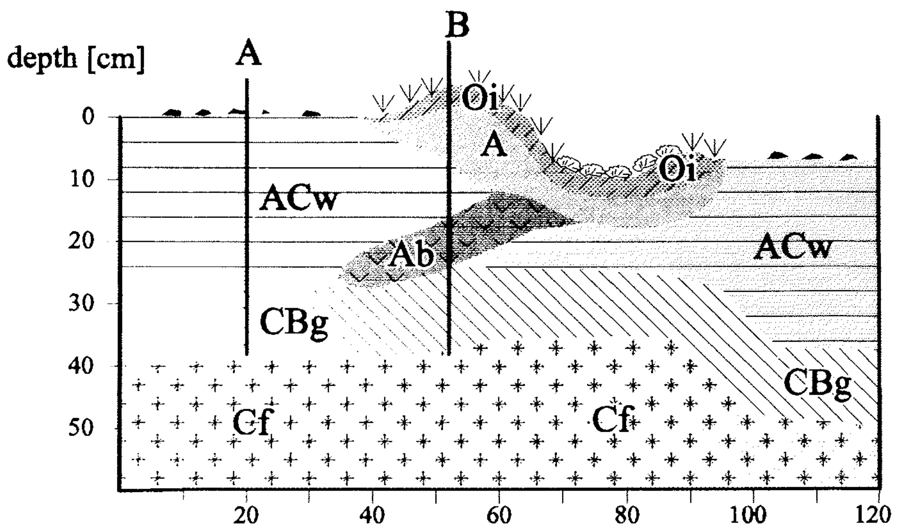


Figure 2-9: Soil profile PG9, nonsorted steps.

2.2.2 Carbon Pools and Soil Organic Matter

2.2.2.1 Primary Production
(H. Becker)

Objective. - The estimation of the NPP is important for many parts of the whole project. In connection with CO_2 flux measurements, CH_4 emission data and the decomposition experiments a conservative estimate of the carbon budget for the polygon tundra in the Krassnaya-Valley will be possible. Together with the remote sensing data and landscape mapping, it is conceivable to scale up the NPP data to a broader area of the Byrranga-Mountains.

The aim of our investigation is to determine the carbon pool size which is stored in the plant material, and how much carbon will be fixed in plants each vegetation period. Interactions between net primary production (NPP) and mineral soils are also the focus of our interests. Therefore the main plant nutrients, cation exchange capacity (CEC) and the important physical soil parameters like particle size soil porosity were analysed.

Two typical vegetation patches (sites 34 and 15) were selected. At these sites soil samples were taken and the above and below-ground plant biomass was estimated by harvesting. At profile 7 only at the end of August aboveground vascular plant biomass was harvested to compare the data with the results from the last year campaign (for the location of the sites see Fig. 2-2).

Site 15: Pergelic Cryaquept

location:	North-Siberia, Taimyr Peninsula, north-west shore of Lake Levinson Lessing (74° N, 98° E)
landform:	hilly, strong solifluction
altitude:	≈ 70 m a.s.l.
vegetation:	wet type of subarctic treeless tundra, dominated by Carex stans, Salix arctica and mosses.
parent material:	sandy loam
pedogenesis:	weathering by frost action, accumulation of fine-earth, solifluction, accumulation of organic material, gleying,
hydrology:	wet slope

horizon	depth [cm]	description
A	0-5	brownish black (10YR3/1) sandy loam, very strong rooted, with 1% reddish mottles
Cg	5-60	brownish black (2,5Y3/1) sandy loam, strong rooted.
Cf	< 60	permafrost boundary

Figure 2-10: Soil description site 15

Material and Methods. - The aboveground vascular plant biomass was clipped off on 0.25 m^2 plots. On every chosen place five parallel samples were taken twice the vegetation period. The harvested plant material was divided into dead and alive for the two major groups monocotyle and dicotyle plants. The first harvesting date was nearly at the beginning of the vegetation period, and the second and last harvest were at the end of the vegetation period. Lichens and bryophytes were collected only once the vegetation period, after the growing season.

The separated plant material was air dried an packed into plastic bags for transport. In our laboratory the material was dried for several days at 60°C until weight was constant.

For the belowground plant biomass harvest 250 cm^3 soil cores were taken with a steel cylinder driven into the soil by a hammer. The first 15 cm of soil on each plot were examined. Therefore in three depths (0-5 cm, 5-10 cm and 10-15 cm) soil material with defined volume were taken out. To separate the roots from the soil, the soil-root samples were washed with water over a sieve with 2 mm mesh size. A second cleaning of the root material in the laboratory was necessary to clean the roots from remained mineral particles. To prevent effects with dispersing chemicals, a Sonorex© ultrasonic-bath was used for cleaning. The cleaned roots were dried for several days at 60°C, until the weight was constant.

Soil samples were collected all five centimetres in the upper horizon of each site. (total carbon, organic carbon, total nitrogen, total phosphorous, pH, CEC and particle size analyses).

First results. - Mean values for total aboveground vascular plant biomass ranges from 41.23 at July 21 to 77.46 g DW/m^2. The calculated aboveground NPP for site 15 is 24.72 g DW/m^2.

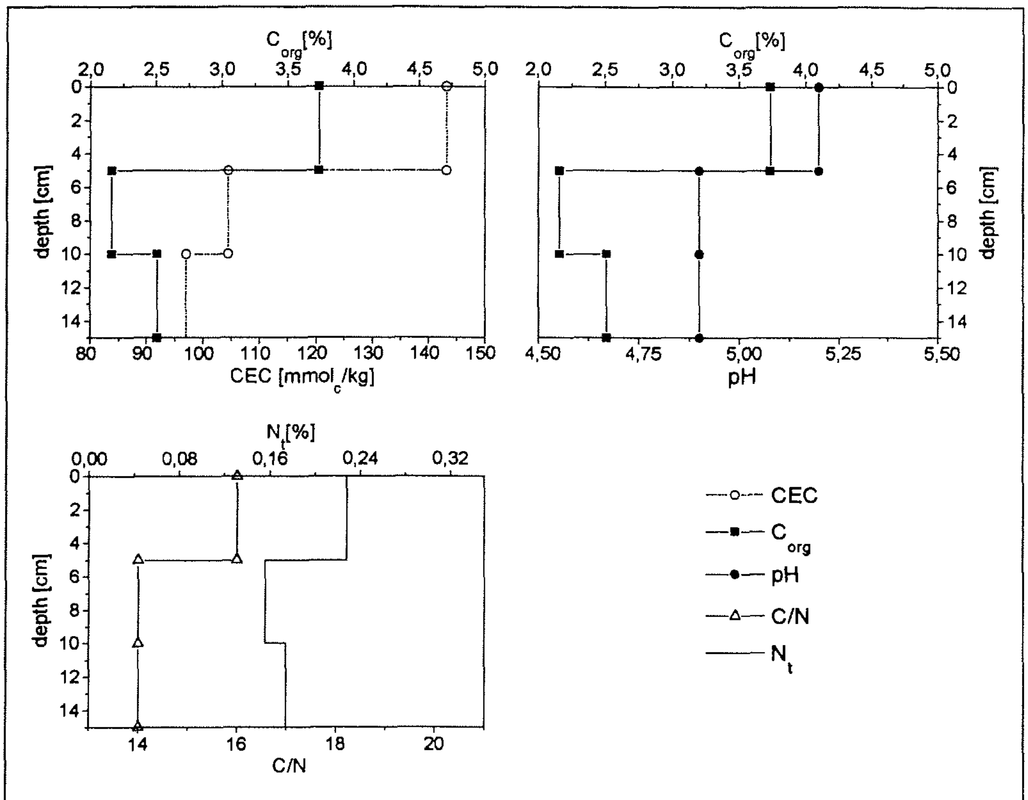
Table 2-1: Dry weight of harvesting fractions of site 15.

harvest date	*21.07.96* DW g/m^2	*17.08.96* DW g/m^2
dicotyle. live	4,65	15,25
dicotyle. dead	3,39	6,19
monocot live	11,90	26,02
monocot dead	36,67	29,82
total aboveground	56,62	77,46
belowground 0-5 cm	584,29	574,23
belowground 5-10cm	339,56	336,23
belowground 10-15cm	198,15	170,21
total belowground	1122,00	1080,67

The differences in the amount of belowground biomass between the two harvests is not statistical significant. The separation between dead and live belowground plant material was not possible, therefore it is impossible to calculate the NPP of the belowground biomass. Table 2-1 shows the detailed data of the vascular plant biomass at site 15.

The analytical data are quite similar to the data found in literature about arctic soils (Everett et al., 1981; Marion et al., 1989). The surface soil at site 15 is moderately acid (pH 5,2); the lower soil layers are strongly acid (pH 4.9). The organic carbon content decreases regularly with the soil depth. The values are ranging from 3,7 % in the upper soil to 2,5 % in the depth. The nitrogen content follows the trend of organic carbon, so the carbon to nitrogen ratio is nearly the same in the whole profile. The CEC ranges from 143.16 $mmol_c/kg$ at the soil surface and 97.04 $mmol_c/kg$ in a depth of 15 cm below the surface.

The correlation between CEC and C_{org} (see Fig. 2-11) indicates that the soil organic matter (SOM) is the most important cation exchange complex in the analysed soil. The analyses of the plant nutrients in the soil are still in progress. The chemical analyses, in connection with the field data, will give more detailed information about the soil/plant interaction.



C_{org}: organic carbon; CEC: cation exchange capacity, N_t: total nitrogen

Figure: 2-11: Organic carbon-, nitrogen-contents, pH, cation exchange capacity and C/N ratio of profile 15

2.2.2.2 Decomposition of Plant Residues and Soil Organic Matter
(A. Gundelwein)

Introduction. - The role of permafrost affected soils as sinks or sources of carbon is determined by the labile balance between production and decay of organic matter. Global warming could have different effects on primary production on the one and on decomposition rates on the other hand (Kirschbaum, 1995).

About 3 % of the worldwide carbon pool are stored in the phytomass of permafrost soils in the Russian arctic territory (Kolchugina & Vinson, 1993). Plant coverage of permafrost soils controls soil temperature and thawing processes (Matveyeva, 1971). Therefore, the knowledge about carbon dynamics, about primary production and decomposition of organic matter is an important part of carbon cycle investigations in permafrost affected soils.

Materials and Methods. - The determination of decomposition rates was started during the expedition in 1995 and completed in 1996. The investigations took place in two different regions: in the typical subarctic tundra at Lake Labaz of the Taymyr Lowland and in the mountain region of the Byrranga Range at Lake Levinson Lessing.

The annual turnover rates were determined with special litter bags (Minicontainer®, Eisenbeis et al, 1995) with different meshsize (0.5 mm and 2 mm), containing typical plant material (*Carex stans* and *Carex bigelowii arctisibirica*, sprout and root material).

The plant material was harvested at the end of the vegetation period in 1995, dried at 105°C and weighed in the field, using a Sartorius Moisture Analyzer® MA 30 (only at Lake Labaz). The Minicontainers were burried at 5 sites, 2 cm below the surface (sites 2, 3, 4, 7 and 15; compare Table 2-2). They were excavated after 1 year at the end of the vegetation period in 1996, dried at 105°C and weighed again. The turnover rates were calculated from the weight loss over that one-year-period. Only 2-5 parallels could be made. The presented data only give the order of decomposition rates. Total organic carbon (TOC) and total nitrogen were determined using a C-H-N-analyzer (HERAEUS Company). The main characteristics of the different sites are listed in Table 2-2.

Results. - The decomposition of plant material under subarctic and arctic climate conditions is depressed by low temperatures and, in wet tundra, by the anoxic conditions.

In the first years of decomposition leaching of soluble substances is the most important process for weight loss. Especially under subarctic and arctic climate conditions leaching is a very important part of the decomposition process, because freezing and thawing cycles cause cellular disruption and release of substrates and nutrients (Swift et al., 1979). After this first leaching phase the rate of weight loss decreases, especially under the low temperature conditions of the arctic and subarctic, where microbial activity is low (Parinkina, 1989; Parinkina & Dokuchaev, 1979; Eisenbeis, 1993; Rustad, 1994).

Table 2-2: Characterization of the investigated permafrost site.

area, site	soil	pH ($CaCl_2$)	patterned ground
Lake Labaz,site 2 a/b	loamy, nonacid Pergelic Cryaquept	a: 4.1 - 6.6 b: 4.5 - 5.4	apex (a) and trough (b), earth hummocks
Lake Labaz,site 3 a/b	loamy, nonacid Pergelic Cryaquept	a: 4.8 - 5.4 b: 5.5	apex (a) and trough (b), small earth hummocks
Lake Labaz,site 4	loamy, nonacid Pergelic Cryaquept	4.1 - 6.3	no patterned ground structure, depression
Lake Labaz,site 7	sandy, nonacid Pergelic Cryaquept	4.2 - 6.3	no patterned ground structure
Lake Lab.,site 15a/b	histic Pergelic Cryaquept	3.2 - 4.7	apex (a) and trough (b), low centred polygon
Lake Lev.-Less.,site7	histic Pergelic Cryaquept	4.1 - 6.3	trough, low centred polygon

Table 2-3: Production and decomposition of organic matter at Lake Labaz 1995 - 1996.

	site 2 apex	site 2 trough	site 3 apex	site 3 trough	site 4	site 7	site 15 apex	site 15 trough
decomposition *Carex* (**sprout**), mesh size **2 mm**, (loss in first year) [%w/w]	24.9	24.9	31.5	20.0	20.2	11.5	26.1	19.9
decomposition *Carex* (**sprout**), mesh size **500μm**, (loss in first year) [%w/w]	22.1	24.3	32.9	13.7	24.3	20.6	15.9	19.8
decomposition *Carex* (**roots**), mesh size **2 mm**, (loss in first year) [%w/w]	0	11.5	5.1	7.3	5.6	0	4.6	0
decomposition *Carex* (**roots**), mesh size **500 μm**, (loss in first year) [%w/w]	0	5.5	12.7	5.3	2.1	7.6	---	---

The plant litter of the excavated Minicontainers shows none or only very little visible mechanical destruction. The weight loss of *Carex spec.* litter lies between 20-30 %. Other reported decomposition rates range from 5 to more than 50 % weight loss in the first year, depending on climate, moisture conditions and plant material (Heal & French, 1974; Swift, 1979; Parinkina, 1989). The decomposition of roots (4-12 %) is much lower than that of sprout material (13-31 %). The weight loss is similiar to that of standardized cellulose material (4.5-7.5 %, Parinkina, 1989).

Higher weight loss of material burried in the wet parts of the microrelief could be explained by higher leaching rates in these parts of the patterned grounds. At site 3 at Lake Labaz additional high temperatures and good aeration in the apex part of the microrelief leads to good conditions for microbial activity and decay of plant material (Table 2-3). The rate of weight loss is be expected to slow down in the next phases of decomposition.

Decreasing carbon and nitrogen contents occur at wet sites (sites 7 and 8 at Lake Levinson Lesssing) as well as at dry sites (site 7 at Lake Labaz; compare Table 2-4). The high loss of carbon and nitrogen at the dry site 7 at Lake Labaz could be explained with good conditions for microbial activity (higher aeration and temperatures).

The meshsize of the Minicontainers does not seem to have a great influence: only in four cases decomposition rates of containers with small meshsizes are lower than those of containers with large meshsizes, in two cases loss of material is higher with smaller meshsizes (Table 2-3). Large meshsizes seem to be an advantage for mass loss only at very wet sites (for more details see Gundelwein et al., in press).

Table 2-4: Carbon and nitrogen contents of the burried *Carex*-litter in 1995 and 1996.

	Lab. site 2 apex	site 2 trough	site 3 apex	site 3 trough	site 4	site 7	site 15 apex	site 15 trough	Lev.Less. site 8 apex	site 7 trough
1995										
C [%]	44.1	44.1	46.4	46.4	45.8	46.9	45.8	45.8	47.3	47.3
N [%]	1.3	1.3	1.0	1.0	1.3	1.5	1.3	1.3	1.8	1.8
1996										
C [%]	43.8	42.9	45.4	42.5	41.9	38.9	46.1	47.5	36.6	37.0
N [%]	1.3	1.5	1.0	0.7	1.0	0.8	1.0	1.1	1.5	1.2
C-loss	-0.3	-1.2	-1.0	-3.9	-3.9	-8.0	+0.3	+1.7	-10.7	-10.3
N-loss	0.0	+0.2	-0.0	-0.3	-0.3	-0.7	-0.3	-0.2	-0.3	-0.6

Summary. - The unfavourable climatic conditions of the Byrranga Mountains seem to lead to lower production rates than at Lake Labaz. The production as well as the decomposition of plant material is highly dependent on the microrelief which controls water and temperature conditions. The aboveground plant material contains much more well soluble and decomposable substances than the root material. Higher weight losses of the burried plant material in the wet parts of the microrelief, no visible mechanical decay of the burried litter after excavation and no differences in weight loss between Minicontainers with different meshsizes prove that leaching is the most important factor of litter decomposition in this subarctic ecosystem and that the activity of soil macrofauna as well as soil microflora is low in the investigated places.

2.2.3 Mapping for Remote Sensing of Vegetation Coverage
(G. Vannahme)

To estimate the CO_2 balance it is necessary to get informations about the carbon storage in soils and organic layers of large areas. For this purpose information about the plant comunities and the vegetation coverage has been collected. The data will be used in combination with remote sensing data to calculate the above ground biomass production and to get information about the large-scale distribution of different plant comunities.

The basis of investigations in the field campaign 1996 has been three Landsat TM images which were taken at different times. One at the end of June, one in the middle of July and the last one at the end of August. These remote sensing data will be combined and verified through information obtained from fieldwork.

The study area extents from the southern to the northern part of the Byrranga Mountains, including the Levinson-Lessing catchment in its central part. The catchment itself was studied most intensively; it is characterized by periglacial forms and shows distinct orographic zonations. The main part of this area is located in the arctic tundra. However, valleys can be classified as typical tundra biomes, whereas higher located (> 500 meters NN) exposed areas are classified as polar desert. The training areas (Fig. 2-12) are different with respect to their relief energy, substrate material, and climate and can be discribed as follows:

1. Valley floor of the Krasnaya River with adjacent slopes.
Vegetation cover is 100 %, dominated by Gramineae. The morphologhy is characterized by ice-wedge polygons, thaw slumps and small deltas. The deltas were formed by small streams which have its source in the surrounding mountains. Due to the strong inclination they carry lots of sediment during snowmelt. This type of landscape plays an important role for the biomass production in the study area.

2. Slopes and ridges located on the north and west side of the Levinson-Lessing Lake area.
V-shaped valleys and troughs dominate most parts of the study area. The vegetation cover is not complete. Material weathered by frost action is mixed with debris.

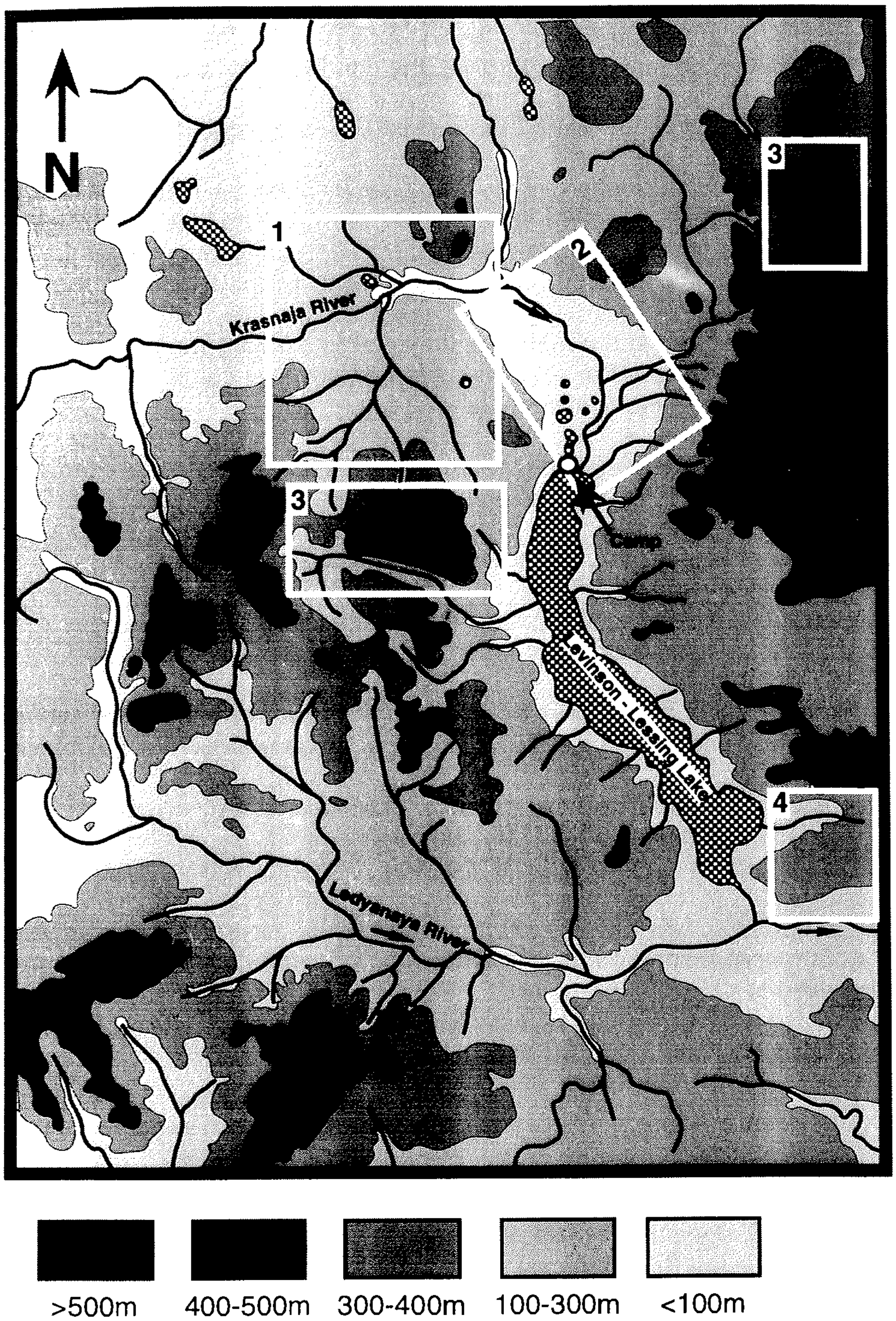


Figure: 2-12: Training areas in the Levinson-Lessing Lake sourroundings (1 - 4) for a remote sensing based classification of the vegetation coverage and surface biomass production (different signatures indicate different altitude intervals).

3. Higher parts of the Byrranga Mountains with deep V-shaped valleys and less vegetation.
Only lichens, mosses and some specialized plants can survive on this exposed location. Due to the long, steep slopes and the intensive frost action combined with permanent sliping gravel, the conditions for plants are bad.

4. Area in the south of Levinson-Lessing lake, densely vegetated and with low relief energy.
However, the rich vegetation cover in the south gives an indication that the micro-climatic conditions are better than in the northern parts although the snow cover persists longer. This kind of landscape dominates the foreland of the Byrranga Mountains and is partial covered only by the sattellite image.

The field work started in the middle of July due to the long winter and the persistend blanket of snow. For each training area serveral points were discribed and measured using the following parameters:

- position, measured with differential GPS with a range of +/- 10m,
- description of the morphology,
- slope angle,
- ratio of vegetation covered and uncovered parts,
- dominant species,
- coverage for each dominating species, and
- average vegetation hight for each dominant species.

All in all nearly 300 points were described with the above-mentioned parameters. Some parameters were measured only at some representative locations:

- soil moisture of the upper 10 cm after at least 5 days without precipitation, using the TDR method
- biomass, in cooperation with the IFB, University of Hamburg.

The aim is to discover the relation between surface biomass and all parameters which were measured for all points. The results of the biomass analysis will be used to calibrate the results for each point relative to the above ground biomass production. Moreover, several controlpoints were surveyed to combine satellite data with a digital elevation model and maps with other information.

2.2.4 Microbial Activity

2.2.4.1 Aerob Carbon Fluxes
(M. Sommerkorn)

The goal of this year´s field season was to achieve data of aerob carbon turnover at Lake Levinson-Lessing during summer. Within the scope of the project these data will allow comparisons between sites on a latitudinal gradient on Taymyr-Peninsula, i.e. Lake Labaz at 72°22´ N, and Lake Levinson-Lessing at

74°32' N. Furthermore, the knowledge about amounts of and parameters determining CO_2-fluxes should be extended to tundra-forms different to those found in the southern tundra near Lake Labaz.

The measuring plots for aerob carbon turnover at Lake-Levinson- Lessing were established some hundred meters away from the field-camp. The main vegetation form in the valley is a wet, low center polygonal tundra. The diameter of the polygons around the plots ranges from 6 to 10 m, the margins with underlaying ice wedges are 10 to 60 cm high. Soils are Histic Pergelic Cryaquepts and Pergelic Cryofibrists. The vegetation of the polygon centers is dominated by Carex stans and Dupontia fisheri on the vascular plant side, and Plagomnium elatum as well as Drepanocladus uncinatus on the moss side. Mosses altogether show a coverage of 100 %, whereas vascular plants cover 80 %. On moderate high polygon margins vegetation shows an increasing rate of dwarf shrubs, especially Dryas punctata, accounting for a total of 35 % of coverage. Total vascular plant cover is 55 %, whereas mosses account for 95 %. Tormenthypnum nitens dominates, representing as much as 75 % coverage. A vegetation mapping exceeding the neighbourhood of the measuring plots could not be established due to the shortness of the field season.

Diurnal *in situ* measurements of CO_2 fluxes were carried out by means of a seven channel infrared CO_2 analyzer (Walz, Germany). The equipment consists of six non-conditioned, non-transparent cuvettes for measuring soil respiration and one conditioned, transparent cuvette for measuring moss primary production and soil cryptogamic coupling. Since both cuvette-systems are operating in open system, They can be used permanently. In order to measure net system carbon flow including vascular plants, transparent hoods were taken. This equipment requires accumulation technique and is operated discontinuously, mostly in one hour intervals.

In order to relate the observed CO_2 fluxes to the ambient clima, all variables that influence aerob carbon fluxes were measured continuously. A climate station (Driessen und Kern, Germany) provided data for air temperature, humidity, radiation, precipitation, pressure, wind speed and direction. Microclimatic measurements of soil temperatures in various depths of the plots were carried out continuously by use of data loggers (Grant, UK). The water status of the soils was analyzed by means of wells and a Moisture Analyzer (Sartorius, Germany). Additionally, active layer depths were measured every day.

During the four weeks field-season from July 20 to August 15 a warm period of roughly one week (until July 27) was followed by cool, cloudy and humid weather (Fig 2-13). Average ambient temperature during the field-stay was 8°C, maximum and minimum were 20°C and 1°C, respectively. Fog was frequent, because Lake Levinson-Lessing was covered by ice until the second week of August. The first snow fell on August 11.

Microclimate at the measuring plots in the polygonal tundra showed differences between polygon center (Fig. 2-14) and polygon margin (Fig. 2-15). Sur-

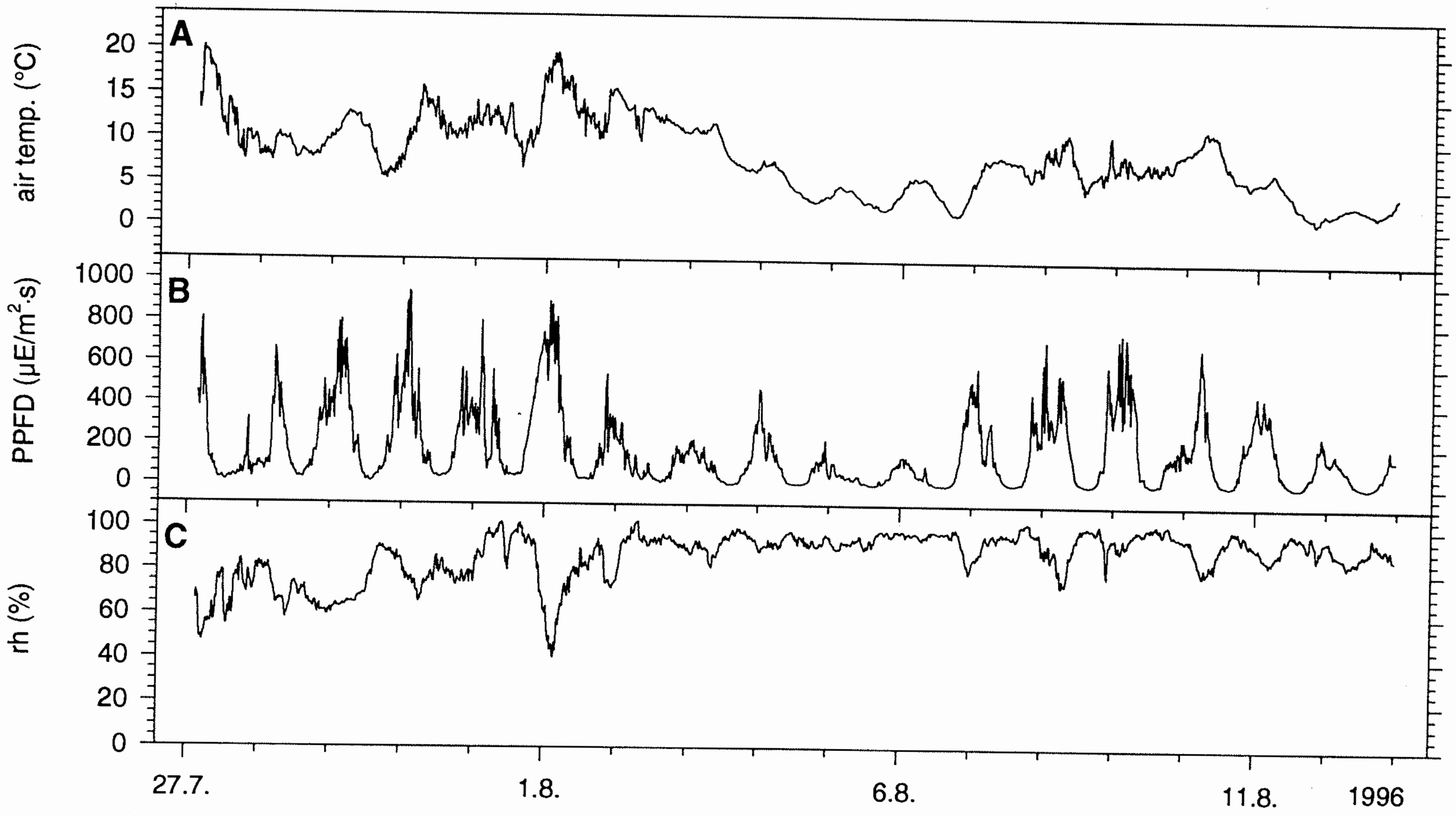


Figure 2-13: Climate data from Lake-Levinson-Lessing valley site for field season 1996. A: ambient temperature, B: photosynthetic photon flux density,C: relative humidity.

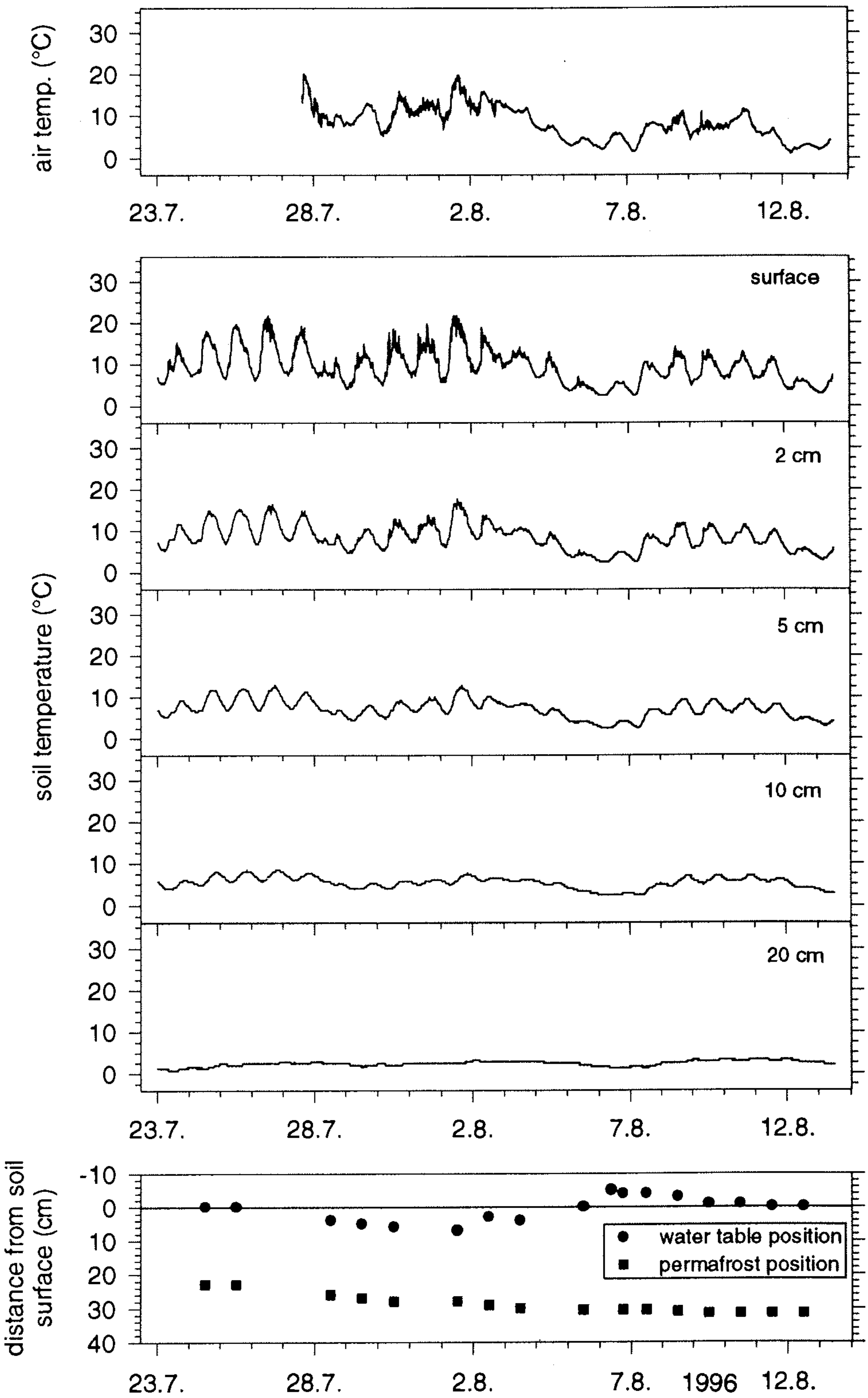


Figure 2-14: Ambient temperature, soil temperatures, depth of permafrost and water table in polygonal tundra, polygon center.

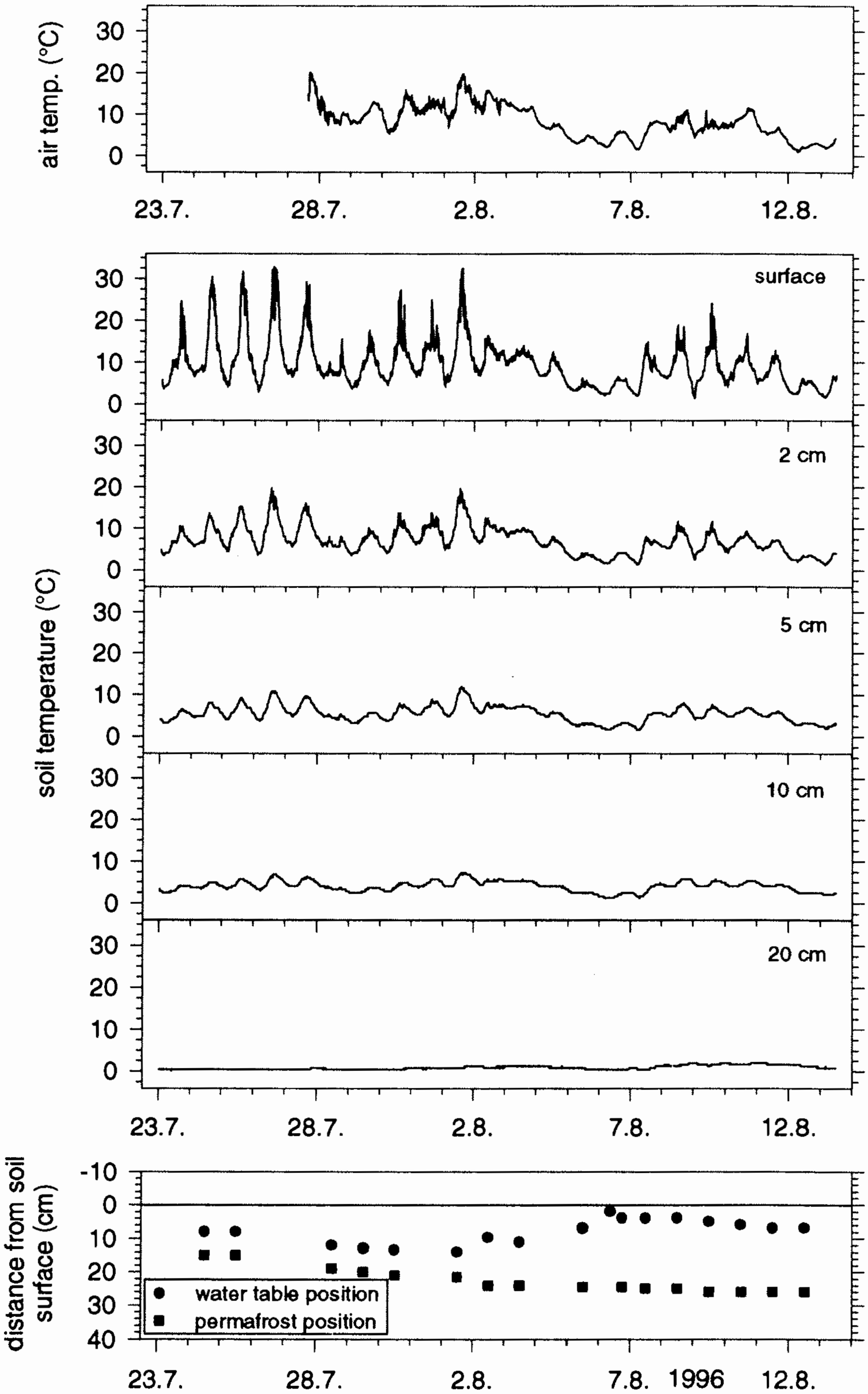


Figure 2-15: Ambient temperature, soil temperatures, depth of permafrost and water table in polygonal tundra, polygon margin.

face temperature on the margins were up to 10°C higher than in the center. Temperature in the deeper soil horizons tended to be somewhat more homogenous in the polygon center. The reason for this, and also for the deeper active layer at the latter plot, can be seen in the higher water table position all through the season in the polygon center compared with the margin. Water table in the center was never found deeper than 7 cm under the soil surface, whereas at the margin it was found as deep as 14 cm. During a heavy rain fall event on August 6, the water table in the center of the polygons raised as far as 5 cm above the soil surface.

CO_2 fluxes of microbial respiration in moderate high polygon-margins showed little higher values than in the polygon center, but a more pronounced diurnal course. CO_2 fluxes were found to be higher than in the wet sedge tundra, but lower than in tussock tundra at Lake Labaz. On the margins, maximum values of 300 mg $CO_2/m^2 \cdot h$ could be observed. As long as the mosses were in full turgor, they were able to refix huge amounts of CO_2 emitted by microbial respiration, keeping the soil-moss-system close to neutral in the sense of net system flux integrated over the day. A first impression of the net CO_2 system fluxes of the whole tundra system shows the polygonal tundra system to be well on the positive side, i.e. being an CO_2-sink, during the days of July.

On order to receive more information about the water status and temperature dependency of the soils and furthermore to allow comparisons of microbial capability between Lake Labaz and Lake Levinson-Lessing soils, core samples as well as monolith samples were taken from the polygonal tundra for laboratory gas exchange experiments.

2.2.4.2 Methane Emissions

(V. Samarkin, A. Gundelwein, E.-M. Pfeiffer)

Introduction

Tundra wetlands could be an important source for the greenhouse gas methane. About 120 Tg methane per year are emitted from natural wetlands (IPCC, 1995). Most important are the wetlands lying between 60-70° northern latitude (Aselman & Crutzen, 1989; Matthews & Fung, 1987). Studies about methane fluxes from tundra ecosystems were already carried out in Alaska (Bartlett et al., 1992; Harriss et al., 1993; Morrissey & Livingstone, 1992; Sebacher et al., 1986; Whalen et al., 1991; Whalen & Reeburgh, 1988, 1990, 1992) and in Canada (Moore & Dalva, 1993). Still very little is known about methane emissions and dynamics from the tundra wetlands in northern Siberia. Only a few measurements at isolated places in the tundra of Siberia were conducted (Inoue et al., 1995; Nakayama, 1995a; Nakayama, 1995b; Rivkina et al., 1993; Samarkin et al., 1994). Some authors have carried out special investigations concerning methane producing and consuming microorganisms (Gilichinsky et al., 1993; Vecherskaya et al., 1993). Northern Siberian wetlands cover an area of more than 211 Mha km2, 2.9 Mha are peatlands (Botch et al., 1995;

Kolchugina & Vinson, 1993). This elucidates the importance of measurements of methane fluxes also from wet tundra in the Siberian arctic.

Material and Methods

Methane emissions. - The static chamber technique was used for measuring methane emissions from tundra wetlands in northern Siberia. The chambers are built out of clear polyacryl, chamber dimensions are 0.5 m * 0.5 m * 0.1 m or 25 l. They were sealed against the soil surface by setting on a waterfilled, stainless steel frame. The air was pumped trough with a small circulation pump. The measurements were conducted within a period of 15 to 30 minutes.

Methane concentrations in the chamber were measured every 90 seconds in a circulating modus by a trace gas analyzer (TGA) 1302 from Bruel & Kjaer Company, Denmark, working with photoaccustic infrared spectroscopy. Two filters with different sensivity were used (UA0969 [> 0.26 ppm methane] and UA987 [> 0.07 ppm methane]).

With the TGA the data were immedeately received in the field, more measurements and a higher resolution were possible. In combination with a small generator this equipment is very mobil in the field and measurements were possible at a lot of different places in short time. Totaly 12 gassamples were taken from the chamber during measurement to compare the TGA-results with results of Gaschromatograph (GC) measurements in laboratory (GC Carlo Erba GC 6000 with Flame Ionisation Detector [FID] and Temperature Conductivity Detector [WLD], Fisons Company). The results of the GC were 1-4 ppm above the results of the TGA, the mean deviation is about 14.5 %. The results of the TGA are reliable when the concentration of methane in the gas is higher than 10 ppm.

Methane emissions were measured in the valley of Krasnaya River, north of Lake Levinson Lessing in Byrranga Range, Taymyr Peninsula, Northern Siberia at 75°N, 98°E. The valley of Krasnaya River is dominated by low centred ice-wedge polygons. The wet, gleyic soils out of loamy sands are rich in organic matter (Histic Pergelic Cryaquepts), maximum thickness of active layer is 45-50 cm. Low centred ice-wedge polygons consist out of two different patterned-ground parts: the central depression (trough), where the water table is near or above surface, and the high border (apex), where the water table is distinctly below the surface. The diameters of the polygons are between 10-30 m, about 33 % of the area are apexes, 67 % are trough-depressions.

Measurements were repeated 4-6 times a day in trough and apex of an ice-wedge polygon in the center of the polygon area. To be sure that these results are representative for the whole polygon area, measurements were carried out at 16 different polygon sites (apexes and troughs) within a transect. By this the variations concerning time (daily and seasonal variations) and area (variations within single patterned ground structures and between different but similar patterned ground structures) were recorded.

Additional experiments with a lowered water table were conducted by the controlled drainage of a polygon-trough and measurement of methane emission depending on water table, using the TGA. Soil temperatures were measured in 5, 10 and 20 cm depth using a hand thermometer. Thickness of active layer, water table, air pressure and air temperature were monitored during every measurement.

Methane concentrations in pore water. - Soil pore waters were taken every 5 cm from the active layer, using a seeper (stainless steel tubing, length: 0.7 m, OD: 3 mm, perforated along the bottom tip 5 cm and covered with cotton, connected at the top with a stopcock and a hand operated vacuum pump). At each sampling depth initial pore water was collected into an in-line stoppered glass flask until bubble free water flow. Pore water sample (10 ml) was then drawn into a pre-vacuumated glass tube (27 ml, Bellco Glass Co.), which was closed with a buthil rubber stopper.

Samples were immediately transported to the field laboratory for analysis. Methane concentrations were determined within 1 hour of collection using headspace technique (McAuliffe, 1971). Methane was quantified with a portable XPM-4 Gas Chromatograph (Chromatograph Company, Russia) equipped with a flame ionization detector (FID) and a 2 m long stainless steel column filled with Poropack Q resin.

Methane production rate measurements. - The microbial methane production rate from ^{14}C-labelled bicarbonate and acetate was measured using tracer technique (Kuivilak et al, 1989, Reeburgh, 1983). Soil samples for the experiment were collected from active layer at six depths between 0-30 cm in 5 cm intervals. Subsamples of 5 cm3 were rapidly transferred into test tubes with a cut off tip, stoppered by rubber plunger from cut end, were moved by plunger to the opposite side of tubes and stoppered by buthil rubber stoppers without any gas phase.

The soil samples in the test tubes were line injected with a syringe through the rubber stopper with 100 µl of ^{14}C-labelled sodium bicarbonate or 2-^{14}C sodium acetate solution with 0.37 MBq. activity. The samples were incubated on different depths of active soil layer at in situ temperatures for 24-72 hours. The experiment was terminated by the injection of 5 ml of 1 M NaOH solution in each tube. Control samples were fixed immediately after tracer injection.

The further treatment of the samples was performed within 1 month at the radioisotopic laboratory. Each tube was inserted into the special rubber stopper through the hole of appropriate diameter. The rubber stopper was equipped with two 3 mm stainless steel tubings with stopcocks for air bubbling. A 100 ml glass jar, containing 50 ml of saturated NaCl solution was closed by this stopper and was connected with the apparatus for combustion of CH_4 formed.

The soil-NaOH-mixture from these tube was injected into the jar by plunger movement and was stripped with air which than passed through (1) a bubbling flask containing 10 ml of 0.5 N NaOH, (2) a quartz tube containing silica granules covered by Co-oxyde catalyst at 800°C to combust CH_4, and (3) a bubble tower with 15 ml of scintillation cocktail containing 10 % phenethilamine to trap the $^{14}CH_4$ derived $^{14}CO_2$. The activity was measured by LS 5000TD, Beckmann Company liquid scintillation counter.

The methane production rates were calculated using the following equation:

$$\text{Rate} = \frac{Ap \cdot C \cdot W}{As \cdot t} \quad \mu g\ CH_4[C] \cdot dm^{-3}\ \text{wet soil} \cdot d^{-1}$$

where *Ap* is the activity of CH_4 formed (dpm), *As* the activity of the added substrate, *C* the substrate concentration in pore waters (DIC or methile carbon in acetate), *W* the soil pore water content, and *t* the time of incubation.

Results

Methane emissions. - The methane emission of the investigated trough decreases during the field season from the end of July until the beginning of September (compare Fig. 2-16). During this time the soil temperature also decreases from 8-10°C to 2-3°C in 5 cm depth. The thickness of active layer rises from 25 cm to 35 cm, until it stagnates in middle of August. The water table of the polygon depression is always above or near the ground surface. At two times (middle and end of August) the water table transgresses the ground surface as a result of heavy raining and the methane emission increases. The methane emission from the daily measured polygon shows no variations within the day.

The emission of the apex part of the polygon lies constantly between 0-5 mg CH_4 / d * m^2 (Fig. 2-17). During the start of the field campaign the soil temperatures are about 3°C lower than the comparable soil temperatures in the trough part of the polygon, at the end of August soil temperatures are nearly the same in apex and trough. The ground water table is always below the surface. Contents of reduced iron in the pore water samples as indicator for reductive conditions are much higher in the permanently water saturated polygon depression than in the apex. The contents of dissolved methane in the soil pore water from permafrost boundary up to 10 cm below the surface are the same in apex and trough (5-10 mg CH_4/l), only in the dryer upper part of the apex the methane content is lower than in the trough part of the polygon (> 1 mg CH_4/l, 2-18 a, b). Tests for the determination of the different microbial activity of soil samples from apex and trough are in progress. Presumably the produced methane was oxidized by methanotropic microorganisms before reaching the surface (Fig. 2-17).

The range of methane emissions from the troughs of the transect were 25-160 mg CH_4 / d * m^2, from the polygon apexes 0-18 mg CH_4 / d * m^2. Methane emissions from the apexes are therefore not very important for the methane emission of the whole polygon area. The mean methane emission of the

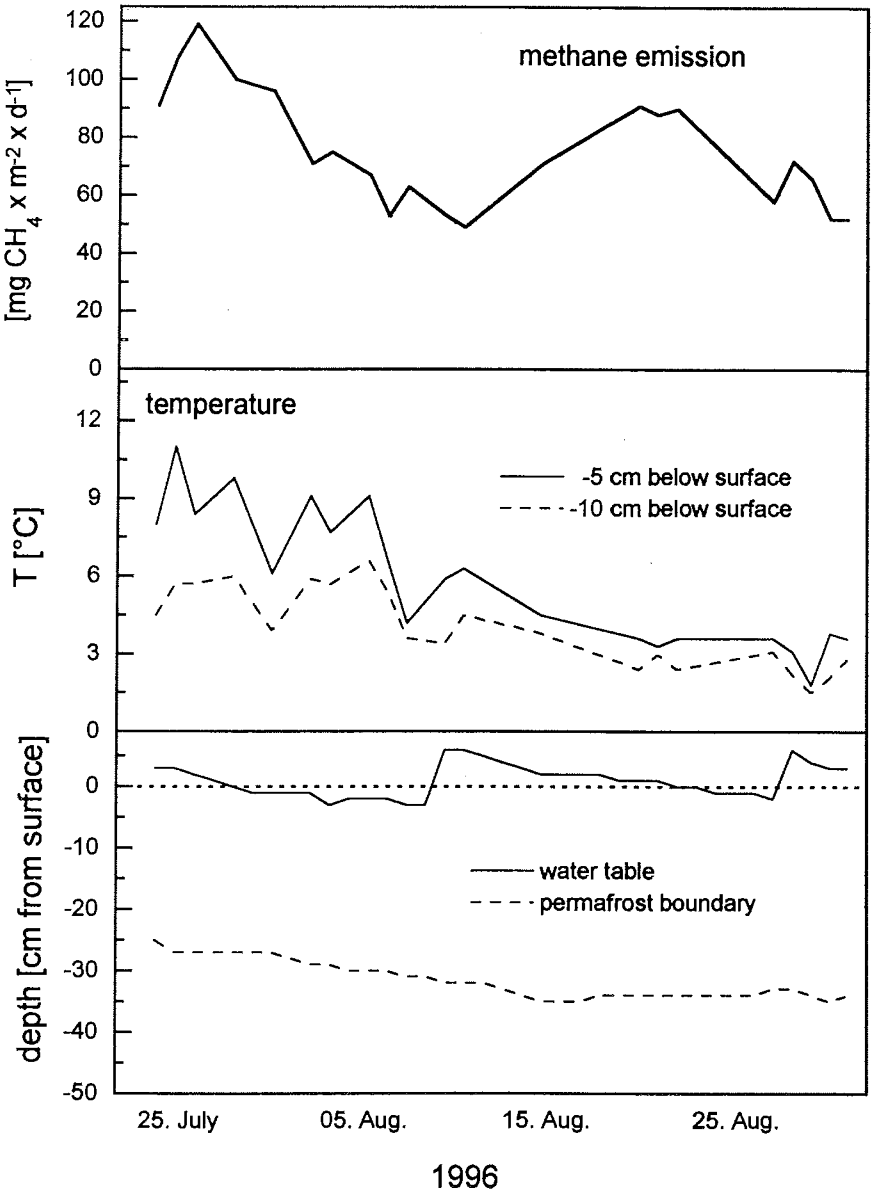


Figure 2-16: Methane emission, soil temperature, and ground water table, polygon trough

whole polygon area of the Krasnaya-Valley is about 55 mg CH_4 / d * m^2 for the time of middle July until the end of August. Both, methane emissions from the trough and from the apex of the single, daily measured polygon are representative for the whole polygon area.

At one polygon trough the water table was lowered in 2 steps from 1 cm above surface to 18 cm below surface over 100 hours. The first step (lowering of water table up to 5 cm below surface) causes a decrease of the methane emission rate from 23 to 16 mg CH_4 / d * m^2. During the second lowering of

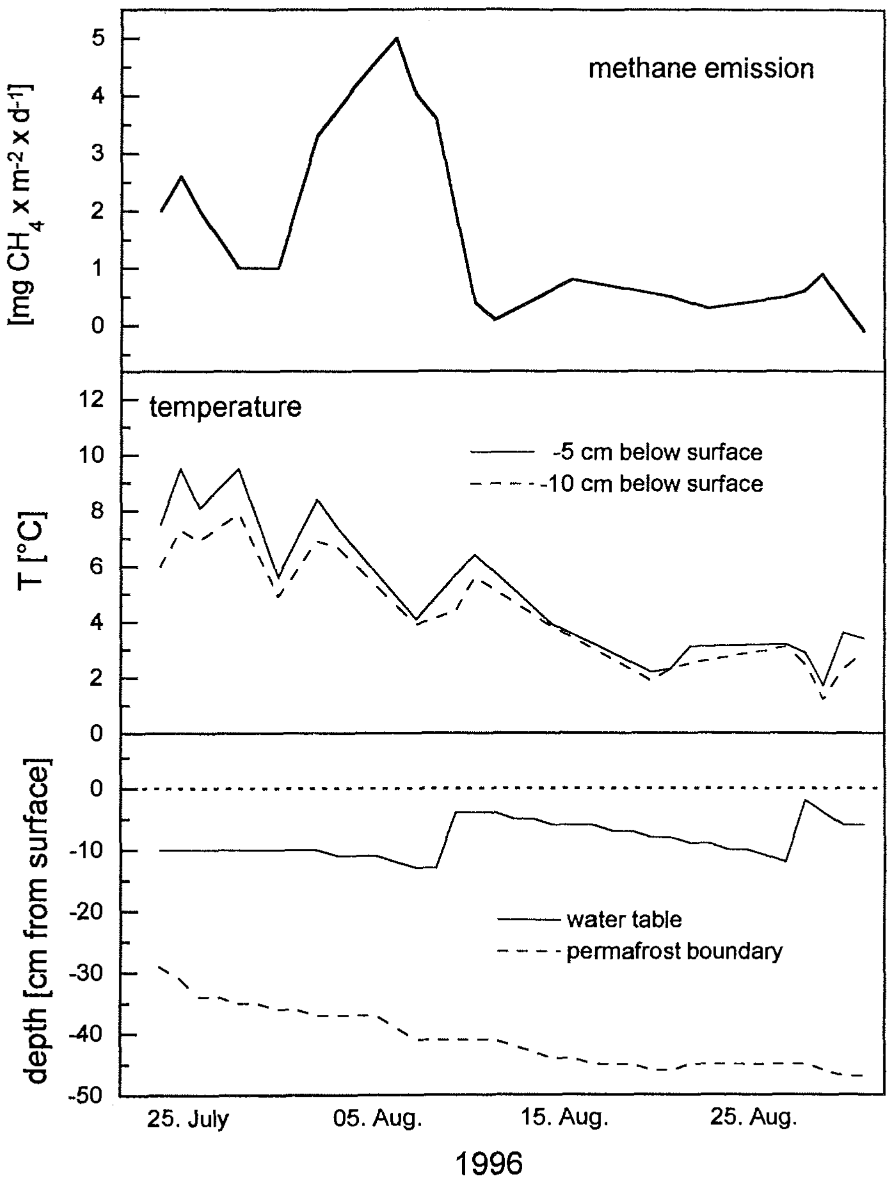


Figure 2-17: Methane emission, soil temperature, and ground water table, polygon apex

the water table up to 18 cm below surface the methane emissions rises up to 37 mg CH_4 / d * m^2 and declines during the following 67 hours again to an emission rate of 16 mg CH_4 / d * m^2 (Fig. 2-19). The slight decrease of methane emission after first lowering of the water table could be explained with disturbance and methane oxidation. The strong increase of methane emission after the second lowering step could be explained by better gas conductivity trough the air filled pores. After this first phase of degasing the methane production decreases and simultaneous the methane oxidation increases, resulting in decreasing methane emissions.

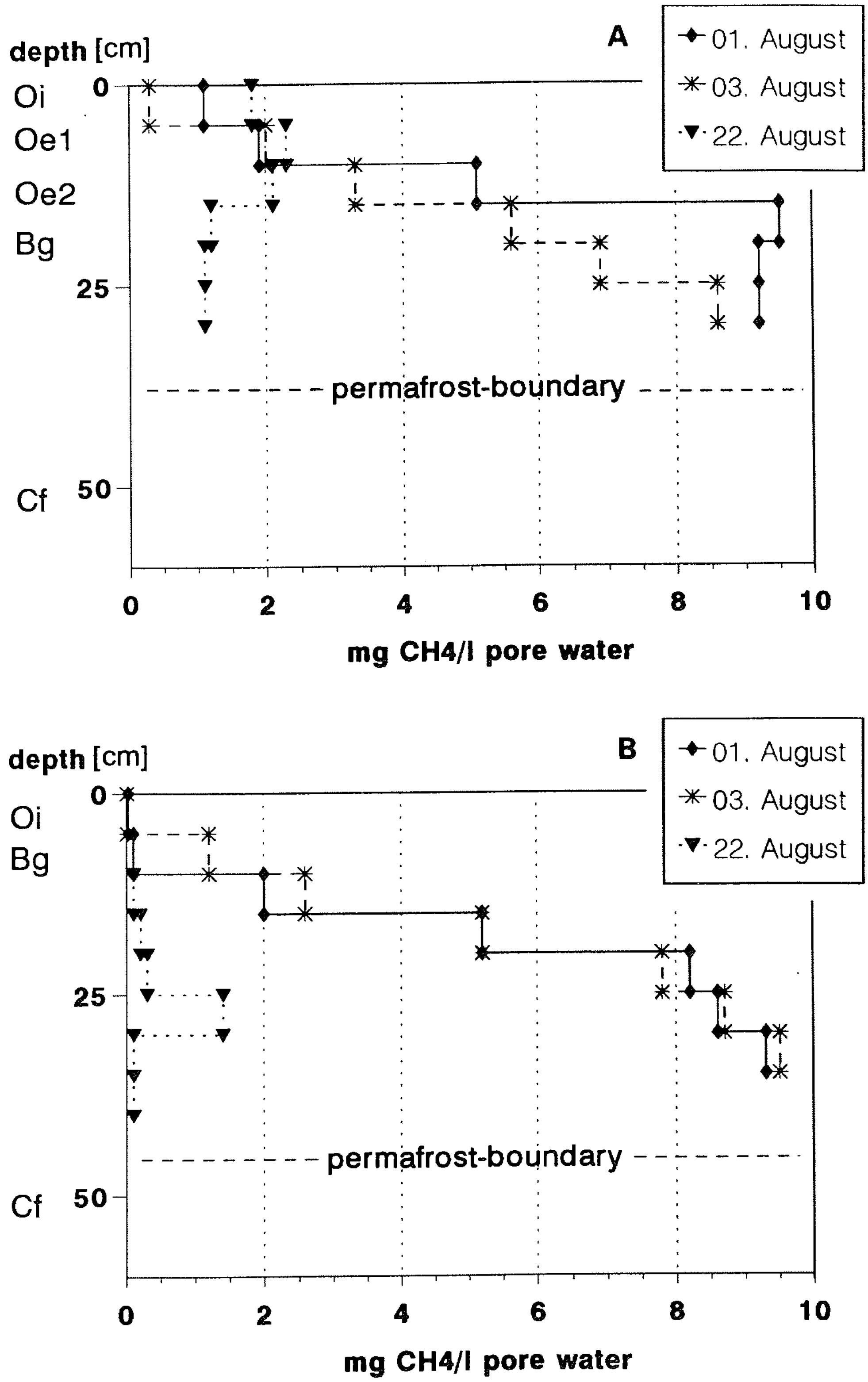


Figure 2-18: Methane content in pore water of polygon apex (upper graph, A) and polygon trough (lower graph, B).

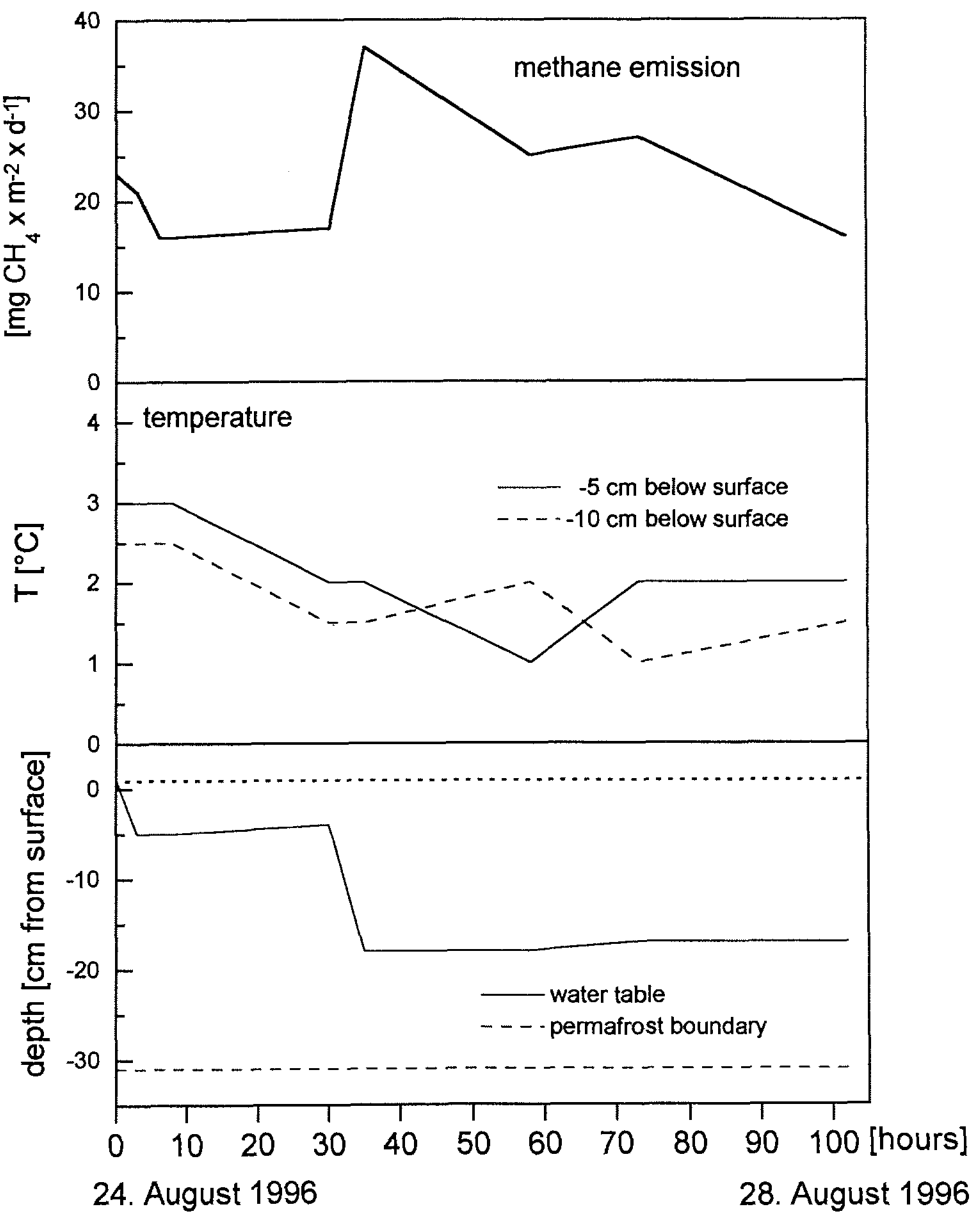


Figure 2-19: Methane emissions during water table lowering.

The methane emission rates are comparable with other rates in the literature: mean daily emission rates between 0-600 mg CH_4 / d * m^2 for wet, subarctic and arctic tundra north of 60°N were reported, most of the reported emisssion rates are between 10-150 mg CH_4 / d * m^2 (Harriss et al., 1993; Inoue et al., 1995; Morrissey & Livingstone, 1992; Nakayama, 1995 a,b; Rivkina et al., 1993; Samarkin et al., 1994; Sebacher et al., 1986; Svensson & Rosswall, 1984; Whalen et al., 1991; Whalen & Reeburgh, 1988, 1990, 1992).

Methane emission rates are controlled by methane production and methane consumption. Both processes are dependent on water table and soil temperature. The presented methane emissions are distinctly dependent on these two parameters. When the water table is low enough, the produced methane is almost totally consumed by microorganisms in the upper, well oxigenized soil horizon. This is the situation in the apex part of the patterned ground. In the trough part of the investigated polygons the emission decreases over time with decreasing soil temperature. When the water table transgresses the soil surface the emission rates increased. The dependence of methane emission rates on soil temperature and water table is known from former investigations (Funk et al., 1994; Harriss et al., 1993; Moore & Dalva, 1993; Morrisey & Livingstone, 1992; Svensson & Rosswall, 1984; Whalen et al., 1991; Whalen & Reeburgh, 1992).

Methane concentrations in pore water. - The methane store in the 30 cm thick active layer of the trough part of the patterned ground, calculated using data from methane concentrations in pore waters (presented in Fig. 2-18 a, b) is 802.8 mg $CH_4 * m^{-2}$ at the beginning of August, and 289.8 mg $CH_4 \bullet m^{-2}$ at the end of August (water content in soil about 60 %). The methane store decreased from 3th to 22th August on 513 mg $* m^{-2}$ or 25.7 mg $CH_4 \bullet d^{-1} * m^{-2}$. This value received by calculation is distinctly lower than the mean methane flux measured by chamber in this period. Methane production in an active layer was measured to determine methane balance in soils.

The integrated production rate in an active layer of soils calculated on the basis of the isotopic experiments (data from 5-8 of August 1996, presented in Table 2-5) is 67 mg $CH_4 * d^{-1} * m^{-2}$. Acetoclastic methane generation contributed about 3.5 % of total methane production.

The stable isotopic composition of carbon and hydrogen in methane dissolved in pore waters $\delta^{13}C$: -60.7 ‰, (δ D: -300‰) confirms that bacterial CO_2/H_2-reduction was the main methane generation process in these soils (Sugimoto & Wada, 1993, 1995).

Table 2-5: Methane generation rates from ^{14}C-CO_2 and 2-^{14}C-acetate.

soil depth [cm]	µg $CH_4 * dm^{-3} * d^{-1}$ from ^{14}C-CO_2	µg $CH_4 * dm^{-3} * d^{-1}$ from 2-^{14}C-acetate
0 - 5	226.0	1.6
5 - 10	345.5	9.6
10 - 15	161.5	11.4
15 - 20	156.4	12.9
20 - 25	321.9	6.1
25 - 30	83.5	2.4
mean	215.7	7.7

The sum of the diurnal loss of methane store (25.7 mg $CH_4 * d^{-1} \bullet m^{-2}$) and the integrated methane production rate (67 mg $CH_4 * d^{-1} * m^{-2}$) show a possible methane flux of about 92.7 mg $CH_4 \cdot d^{-1} \cdot m^{-2}$ if no methane oxidizes in the upper part of the active layer. By compaing this value with the mean chamber derived flux rate from the polygon depression of 73.2 mg $CH_4 \cdot d^{-1} \cdot m^{-2}$ it is possible to believe that more than 20 % of the produced methane was oxidized.

Conclusions

High arctic tundra can produce high methane fluxes, comparable to data from tundra ecosystems in Alaska and Canada. An important part of the produced methane is oxidized in the upper parts of the active layer. For calculation of total methane fluxes from the tundra ecosystem more data are necessary. Especially the variations between different plant-patterned ground units and gas fluxes from high-arctic regions over the whole vegetation period must be investigated. Details of the dynamics of methane production can be investigated by more tracer experiments. To understand the processes of isotopic fractionation studies of the isotopic composition of all mineral and organic compartiments including methane gas are in progress.

2.2.4.3 Microbial Habitat
(M. Bölter, N. Schmidt)

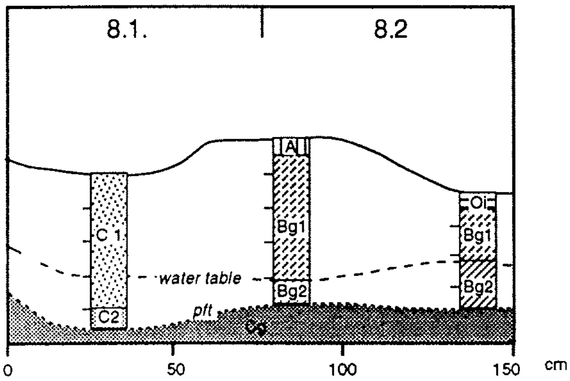
In order to achieve a better understanding of the underlying microbiological processes, the studies of 1995 (Bölter, 1996) have been continued and extended at Levinson-Lessing Lake during this year's expedition.

In contrast to other pedological studies soil microbiological investigations need a change of scale. Soil as a microbial habitat can be regarded as an assemblage of microsites, which are formed by abiotic factors (*i.e.*, soil water and atmosphere, redox potential, pH, soil temperature and light). Due to cryoturbation and varying drainage the soils of the study area are exceptionally heterogeneous on a visible scale. As a result the soil profile description and sampling method has been altered to account for the high heterogenity, which by definition is neglected by the traditional systems (*e.g.*, USDA Soil Taxonomy, FAO World Reference Base for Soil Resources). Micromorphological studies (Miediema, 1996; FitzPatrick, 1993) have shown that these changes can even be observed at a microscopic level (e.g. orientation of rock fragments, humus coagulation, formation of platy microstructures by ice lenses). In combination with core samples for soil thin sections this study is therefore aimed at a description of the microsites on a microscopic level.

The soil sites (Table 2-6) represent typical locations (i.e., Krasnaya-Valley, solifluction slope, tophill situation), forms of patterned ground as well as stages of development (*e.g.*, profile LL1: nonsorted step overgrown, profile LL8: nonsorted step with bare mud pit) of the soils of the study area. Soil description followed the procedure described in Chapter 2.2.1. Profile LL8 (Fig. 2-20) exemplifies that for the above mentioned reasons the required minimum size of a soil profile (*e.g.*, 0.8 m in width, AG Bodenkunde, 1994) is neglected.

Profile LL8/96: **loamy/sandy Pergelic Cryaquept**

location:	North-Siberia, Taymyr Peninsula, northern shore Levinson Lessing Lake (74°N, 98°E)
climate:	continental, mean annual air temperature -14.5°C, mean January air temperature -33.1°C, mean July air temperature 6.5°C, mean annual precipitation 283mm
relief:	slope
altitude:	80m a.s.l.
parent material:	kolluvium
patterned ground:	solifluction slope, non sorted steps
drainage:	imperfectly drained, slope water above permafrost



8.1. mud pit

depth (cm)	horizon	description
0-40	C1	sandy loam, 2-10 vol.% gravel, very dark gray (2.5Y 3/1), no humus, no roots, pH ($CaCl_2$) 5.5, Dipyridyl (-)
40-46	C2	sandy loam, 2-10 vol.%gravel, black (5Y 2.5/1), no humus, no roots, pH ($CaCl_2$) 5.3 , Dipyridyl (-)
>46	pft	permafrost table

8.2. vegetation ring

depth (cm)	horizon	description
0- 5	A	loamy sand, 50-75 vol.% gravel, very dark gray (7.5YR 3/1), weakly humous, pH ($CaCl_2$) 5.7
(0- 5	Oi	weakly decomposed plant material, densly rooted, pH ($CaCl_2$) 4.6)
5-42 (5-27)	Bg1	loamy sand, 10-25 vol.% gravels, very dark gray (2.5Y 3/1), no humus, weakly rooted, pH ($CaCl_2$) 5.3, iron oxides, Dipyridyl (-)
42-46 (27-35)	Bg2	loamy sand, 2-10 vol.% gravel, black (5Y 2/1), no humus, no roots, pH ($CaCl_2$) 5.3, Dipyridyl (+)
>46 (35)	pft	permafrost table

Figure 2-20: Description of Profile LL8/96.

Bag samples were taken along the horizon notations including subhorizons. Special features (*e.g.*, ferruginated fabric, roots, stones with silt cappings) were also sampled. Samples for pedological analyses have been air-dried (as far as climatic conditions allowed) and sieved through a 2 mm mesh sized sieve. Samples for microbiological studies (*e.g.,* cell counts, estimation of microbial carbon (C_{mic}), ATP content) have been kept fresh and stored in a permafrost pit, which served as a refrigerator. Core samples for thin sections of the top 4 cm of a soil have been taken from 100 cm^3 cores, where feasible (see Table 6.4 in Annex).

Table 2-6: Sampling sites for soil microbiological investigations (sample lists see Tables 6.2 - 6.3 in Annex).

	profile	location (see Fig. 2-3)	soil type	remarks
Krasnaya-Valley				
low centred polygon	LL 1/96	8	Pergelic Cryaquept	mound
	LL 2/96	7	histic Perg. Cryaquept	centre
high centred polygon	LL 3/96	22A	Pergelic Cryaquept	centre
	LL 4/96	22B	Pergelic Cryaquept	mound
transitional polygon	LL 5/96	23A	Pergelic Cryofibrist	centre
	LL 6/96	23B	Pergelic Cryofibrist	mound
	LL 7/96	23C	Pergelic Cryaquept	frost crack
Solifluction slope				
nonsorted steps	LL 8.1/96	near 34	Pergelic Cryaquept	mound
	LL 8.2/96	near 34		vegetation ring
nonsorted steps	LL 11.1/96	near 34	Pergelic Cryaqu.	overgrown mound
	LL 11.2/96	near 34		vegetation ring
Tophill				
nonsorted stripes	LL 9.1/96	33A	Pergelic Cryorthent	apex
	LL 9.2/96	33B		trough
nonsorted stripes	LL 10.1/96	32	Pergelic Cryorthent	apex
(transitional to nets)	LL 10.2./96			trough

In the field the following analyses have been carried out: The water content of the sample after sampling has been analyzed gravimetrically after rying at 105°C with a Sartorius Moisture Analyser MA 30 (for results see Table 6.3 in Annex). The pH of the fresh soil sample has been measured in 0.01 M $CaCl_2$ suspension (for results see Table 6.2 and 6.3 in Annex).

2.2.5 Soil Micromycetes

(I. J. Kirtsidely)

Introduction. - Soil micromycete investigations were carried out in two parts during the expedition in 1996: firstly in the Levinson-Lessing Lake area with field studies on microclimatic conditions, and secondly at many site near Khatanga River (Khatanga environments, its tributanes, and Khatanga gulf coast).

The interest of the adaptation of organisms on extreme climatic conditions has increased in recent years in connection with the intensification of antropogenic influence on the environment. Soil micromycetes are the compulsory, but the most poorly investigated part of every natural biocenoses. They contribute to all processes taking place in soils.

2.2.5.1 Micromycetes at Levinson-Lessing Lake

Objectives. - During the seasons 1994 and 1995 micromycetes complexes have already been studied in different biocenoses of the Levinson-Lessing Lake The main objectives for the field work in 1996, therefore, were

- to determine changes of micromycete comunites in soils in dependence on temperature and other microclimatic changes (in spring), and
- to investigate the altitude influences on the soil micromycete complexes, in the mountainous landscape of the Levinson-Lessing Lake area.

Methods. - The work has been performed from June 15 to July 13, 1996. On the collection of samples for soil micromycetes investigation the following methods were used:

- soil sampling for the analysis and identification of micromycetes species; samples were collected under sterilisation condition, subsequently dried up to air-dry condition, followed by laboratory analysis (methods of pure cultures and nutriment medium);
- filter membrana methods for determination of micromycetes biomass in soil;
- methods of the isolation of grows mycelium;
- methods of bait.

Experimental typical plots were placed on a mountain slope in the Krasnaya River valley (4 km from the Levinson-Lessing Lake). Additional plots (with 10 repetition) were placed on the southern, northern, western, and eastern slopes (inclination near 30°).

Results. - Air temperatures on the soil surface, soil temperatures in a depth of 5 cm, soil moistures, and depths of permafrost were measured on the experimental plots. Figure 2-21 presents an example of results from the western slope.

Preliminary results from laboratory analyses indicate that no clear correlation exists between the request of soil temperatures and the colony forming unit numbers of soil micromycetes (in all experimental plots). A rather clear correlation, in contrast, was determined between the request of soil temperatures

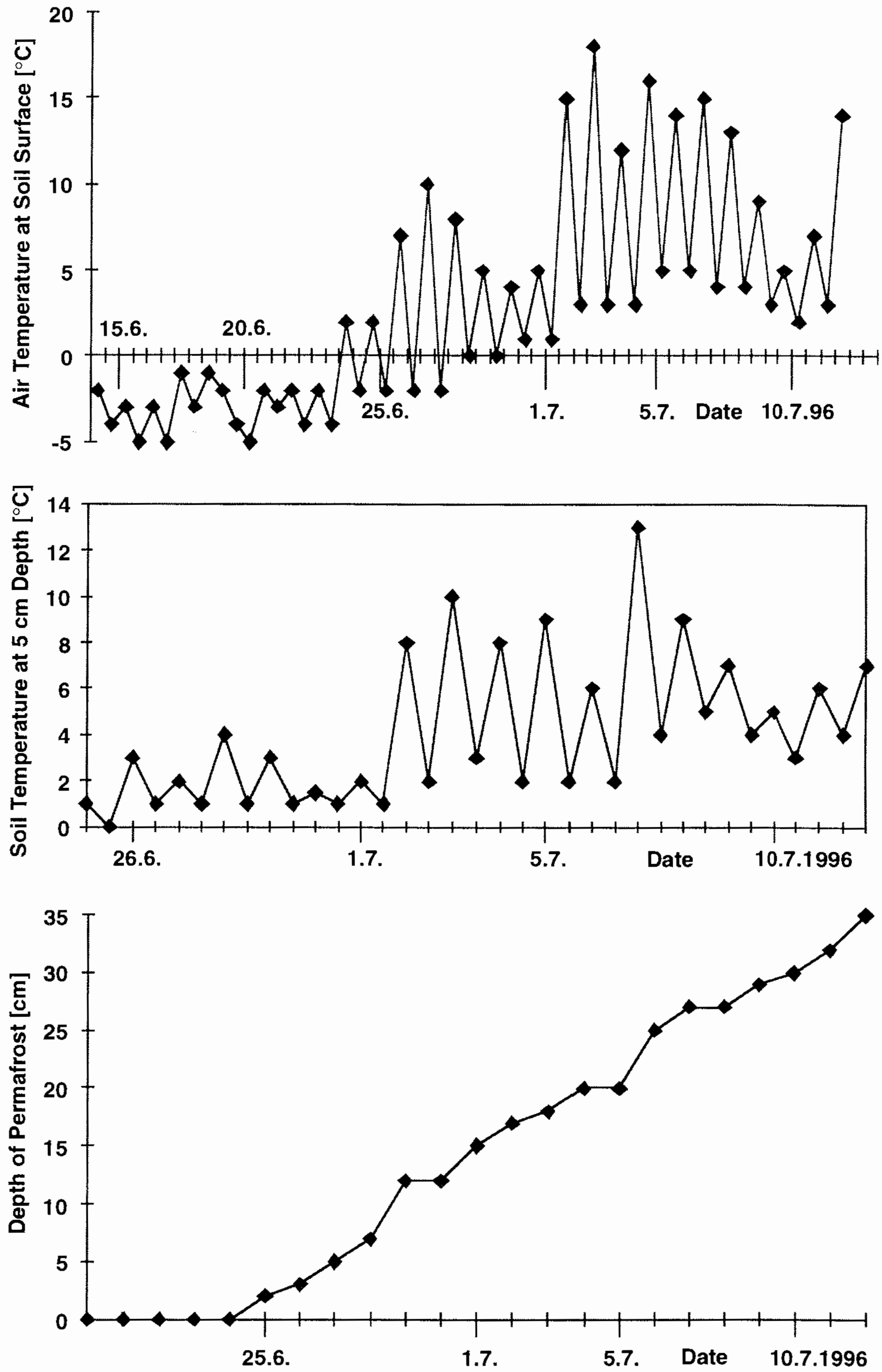


Figure 2-21: Microclimatic conditions (air temperatures on soil surface, soil temperatures in 5 cm depth, and depth of permafrost) at the experimental plot on the western slope for micromycetes investigations.

and the mycelium biomasses of soil micromycetes. The complexes of micromycetes show cardinal differences in the individual experimental plots.

2.2.5.2 Micromycetes at Khatanga River

Objectives. - In the investigated area along the Khatanga River, the vegetation zones change from Northen Taiga to Arctic Tundra. Together with the vegetation zones, changes occur also in the soil complexes of micromycetes, species diversities, and quantities and biomasses of soil fungi in the main plant communites. The aim of this work part, therefore, was the study of micromycete complexes in soils of vegetation complexes reflecting the Northern Taiga, Forest Tundra, Southern, Typical and Arctic Tundra.

Table 2-7: Station list for soil micromycetes investigations along the Khatanga River.

No.	Area	Location	Date	Vegetation Zone
1.	Heta River Environment	71°31´ N 99°24´ E	23.07.96	Northern Taiga
2.	Kotyi River Environment	71°30´ N 103°11´ E	24.07.96	Northern Taiga
3.	Kotyi River Environment	72°40´ - 72.00´ N 102°45´ - 102°00´ E	19. - 22.07.96 26.07 - 02.08.96	Forest Tundra
4.	Khatanga River. Environment	72°29´ N 104°14´ E	03.08.96	Forest Tundra/ Southern Tundra
5.	Khatanga River . Environment	72°27´ N 103°30´ E	13.08.96	Southern Tundra
6.	Khatanga River. Environment	72°45´ N 104°50´ E	12.08.96	Southern Tundra
7.	Khatanga River. Environment	72°46´ N 105°14´ E	25.07.96	Typical Tundra
8.	Khatanga Gulf Coast	73°11´ N 106°20´ E	04.08.96	Typical Tundra
9.	Khatanga Gulf Coast	73°39´ N 109°42´ E	07.08.96	Arctic Tundra

Methods. - The work has been performed from July 15 to Aug. 14, 1996. The following methods were used on this collection of samples for micromycetes investigation:

- collection of samples for the analysis and identification of micromycetes species; samples were collected under sterilisation

condition, subsequently dried up to air-dry condition, followed by laboratory analysis (methods of pure cultures and nutriment medium);
- filter membrana methods for determination of micromycetes biomass in soil.

In all vegetation zones samples were collected both from the main biocenoses of the respective zone and from interzonal vegetation biocenoses and antropogenically polluted soils.

2.2.6 Further Planning
(E.-M. Pfeiffer)

The laboratory work, especially the fractionation of SOM and the isotopic analysis is still in progress and will be finished during summer 1997. After the workshop at St. Petersburg in autumn 1996, where the first results of the single groups were presented, the results of the project will be published in a number of publications (Polarforschung, Pedobiologia, Soil Science) and discussed at the International Symposium on Frozen Soils in Fairbanks/ Alaska and at the International Conference on Cryopedology in Syktyvka/ Russia in summer 1997. Meetings between the members of the single groups will intensify the entanglement of the work of the single project groups, for example the connection between remote sensing und primary production (Potsdam and Hamburg), the balance of carbon in- and output in connection with the microbial habitats (Hamburg and Kiel), the isotopic composition of methane, SOM and lake sediments (Pushino, Hamburg and Potsdam)

2.3 Hydrological and Sedimentological Studies

In the 1996 field season, from June 11 to 15 August 15, the investigations of recent hydrological and sedimentological dynamics, started in 1994 (Siegert & Bolshiyanov, 1995; Bolshiyanov & Hubberten, 1996), were continued in the Levinson-Lessing Lake catchment area (Fig. 2-22).

These studies include investigations of
- the microrelief and temporal variations in active layer depths,
- the active layer water and energy balance,
- water and sediment discharge of stream inflows,
- hydrological and sedimentological processes in the Levinson-Lessing Lake, and
- methane biogeochemistry in Levinson-Lessing Lake.

Furthermore, automatic weather records were measured. Figure 2-23 shows the daily mean air temperature and precipitation (rain) during the field season 1996.

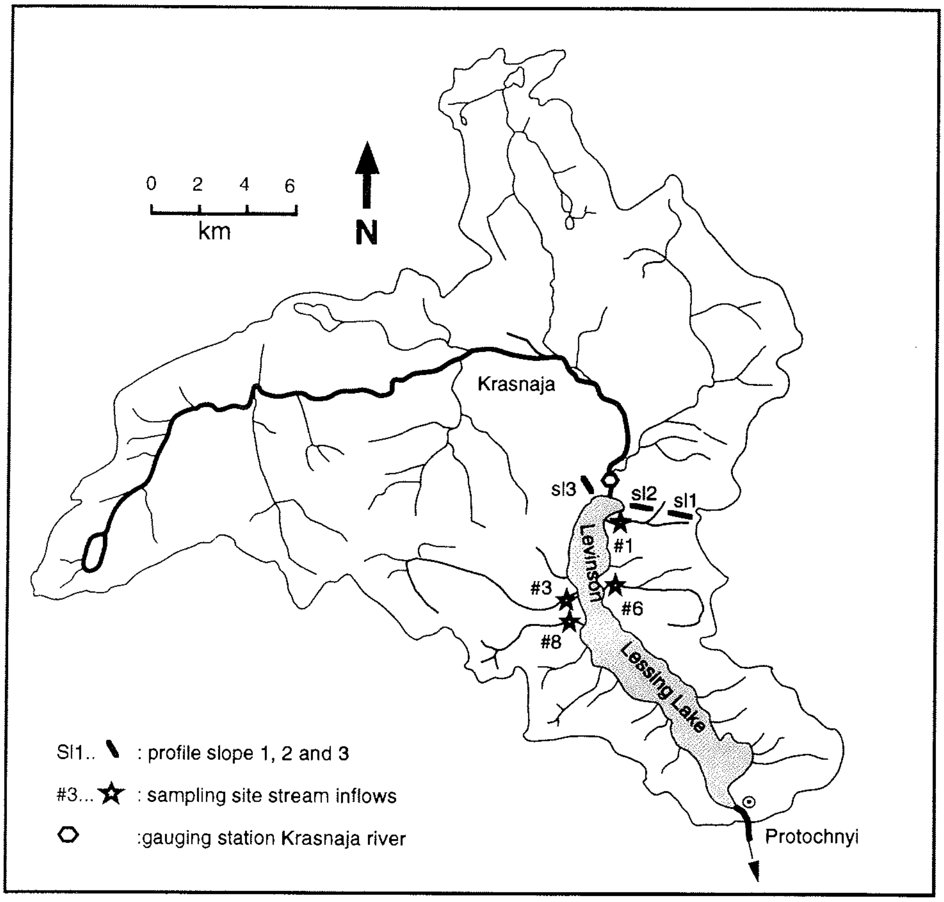


Figure 2-22: Catchment area of the Levinson-Lessing Lake with sampling sites.

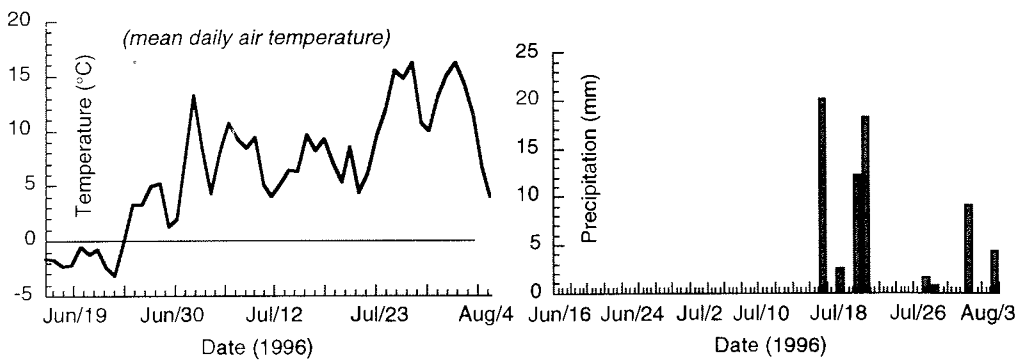


Figure 2-23: Mean daily air temperature and precipitation, recorded with an automatic weather station on slope 2 (for location see Fig. 2-22).

2.3.1 Microrelief and Temporal Variations of Active Layer Thickness

(M.A. Anisimov, O.I. Panasenkova)

During the 1996 field season cryogenic studies were carried out in the northern surroundings of Levinson-Lessing Lake. A measuring field and several measuring transects were investigated with respect to microrelief and to temporal variations in active layer thicknesses (Fig. 2-24). The location of the measuring field was selected in the typical polygonal tundra so that it included several polygonal elements (sedge bogs with a different extent of moistening and ridges). The field size was 30 x 30 m with measurement points located at corners of 1 x 1 m squares.

During the period with positive temperatures, three series of measurements of the thawing depth in the field were performed, at July 2, July 19, and Aug. 10, 1996 (Figs. 2-25, 2-26, 2-27). For obtaining a statistical distribution pattern of the thawing depth in the measuring field elements relative to the relief forms

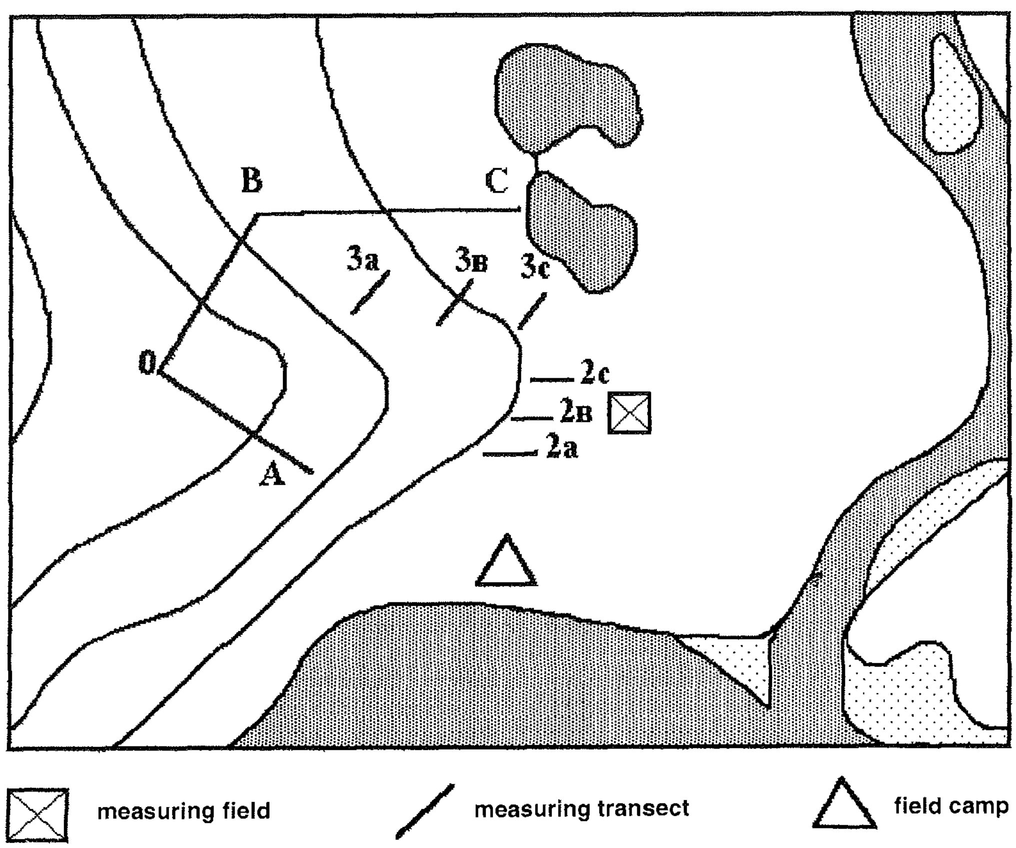


Figure 2-24: Map of the northern surroundings of Levinson-Lessing Lake showing the locations of the measuring field and transects investigated for microrelief and temporal variations in active layer depths (the triangle marks the position of the field camp).

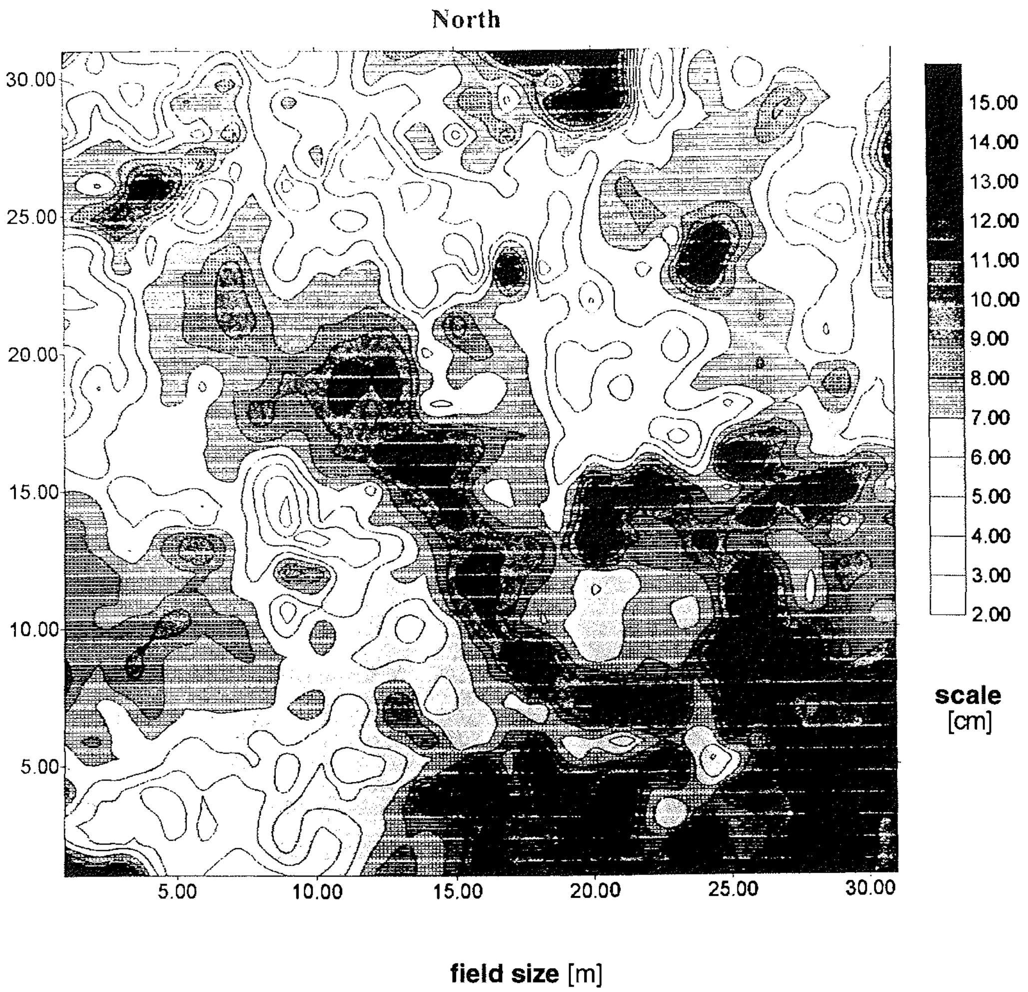


Figure 2-25: Active layer depths in the measuring field at July 2, 1996 (for location see Fig. 2-24).

(polygonal depression-ridge), a levelling survey of the polygon was carried out. It confirmed the presence of three levels of polygonal depressions (Fig. 2-28).

Without the analysis of meteorological data it can already be suggested that there is a certain relation between the relief and the thawing depth at the different forms of microrelief and at different times in the observational period. Thus at the initial stage the rate of snow melting in different parts of the measuring field plays quite an important role. Due to non-uniform snow melting at some field elements, there was a delay in surface heating resulting in less deep thawing of the ground.

A practically complete disagreement between the diagrams made from the results of the levelling survey and the thawing depth measurements of July 2

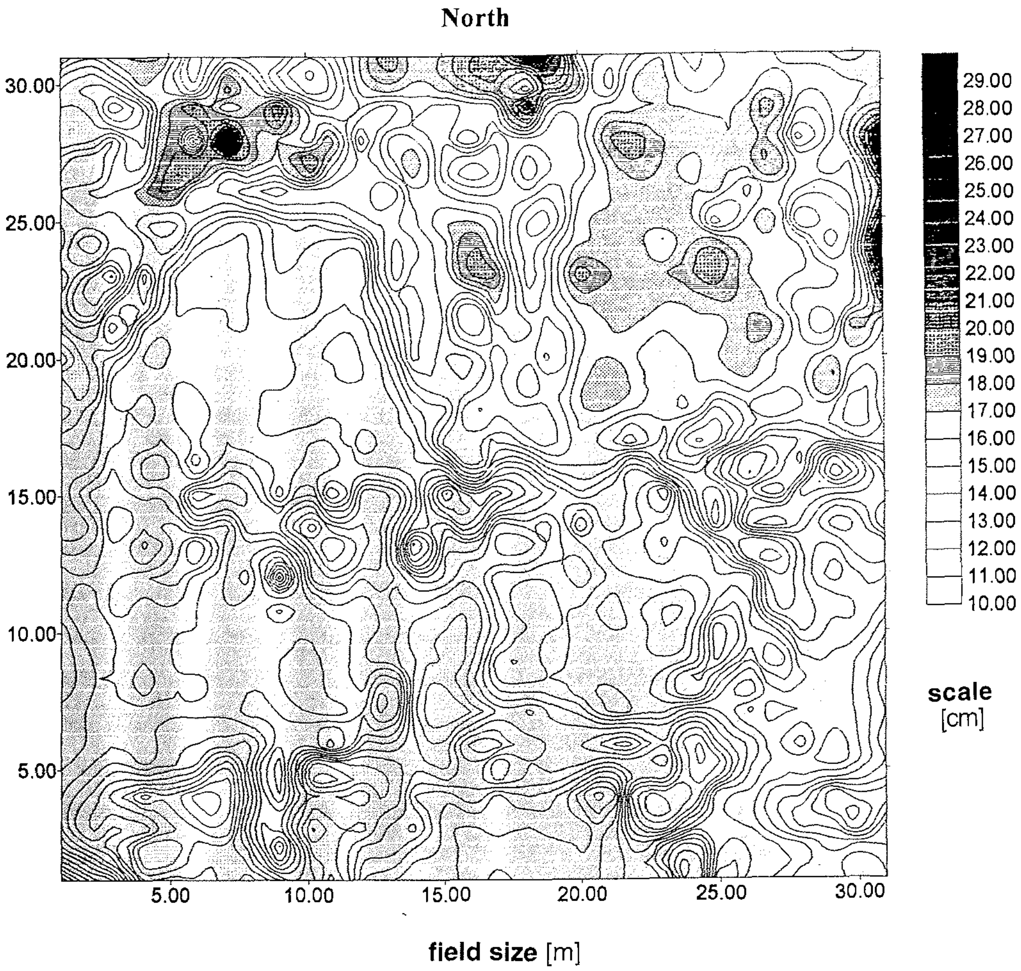


Figure 2-26: Active layer depths in the measuring field at July 19, 1996 (for location see Fig. 2-24).

indicates that at this stage of ground thawing, there was no relation between the relief and the dynamics in the seasonal frozen layer.

To be more exact, it depends on a large number of parameters. The largest similarity in the dia-grams of the relief and the thawing depth was observed in the middle of summer (July 17). By this time, all polygonal depressions were filled with water and the influence of non-uniform snow melting was equal. It appears that the survey of Aug. 10 reflected a non-uniform internal soil structure which is confirmed by test measurements at this polygon at Aug. 18, 1995 (Fig. 2-29).

Unfortunately, we do have available a detailed distribution pattern of different vegetation species in the measuring field and cannot speak unambiguously about the relation of the thawing depth of the frozen horizon to the character

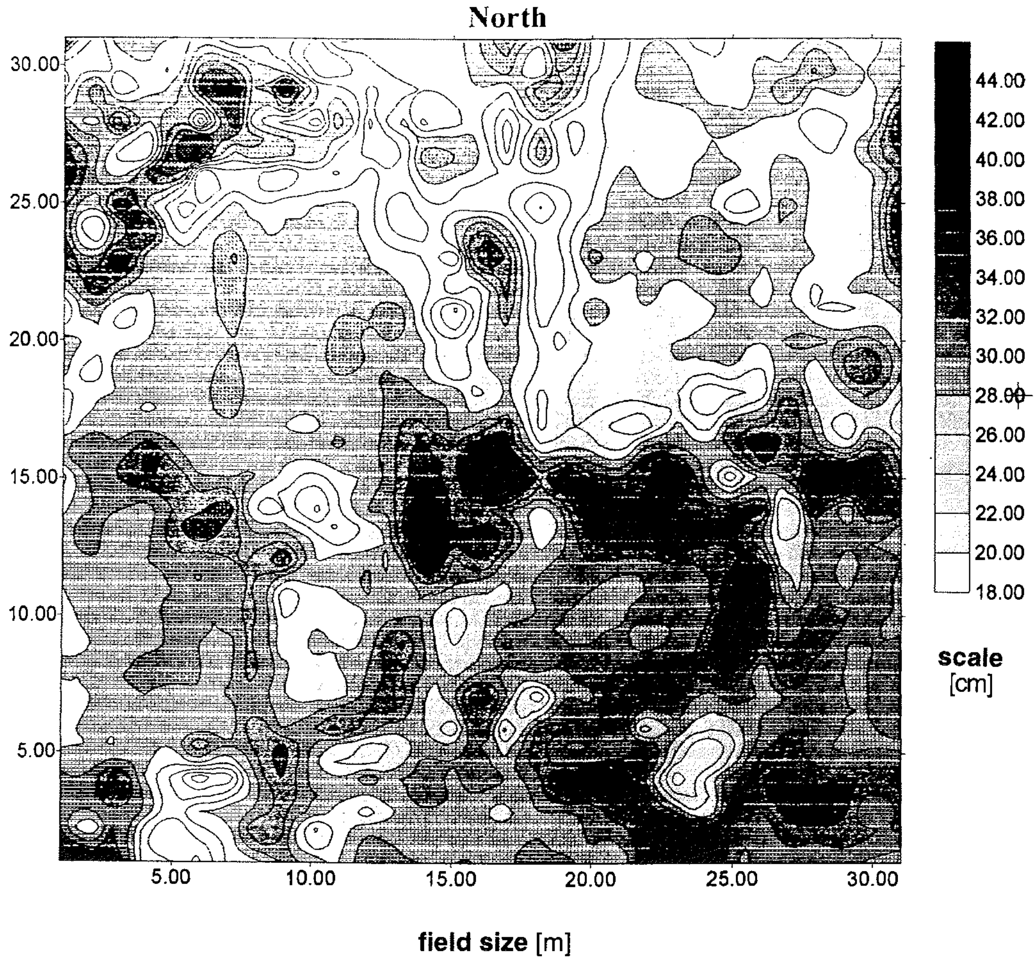


Figure 2-27: Active layer depths in the measuring field at Aug. 10, 1996 (for location see Fig. 2-24).

of the vegetation cover. However, there is an indirect relation between the vegetation cover and the relief.

For observations of the active layer dynamics at the other landscape elements, a profile from the southern slope of the relic (above the observational profile of the German expedition participants) across the saddle at the relic top and farther along the northern slope to the thermokarst lake at the first terrace of the Krasnaya River was made (Fig. 2-24). In total, 8 measurements at 20 points were performed along the profile. The levelling line was passing across this profile. The observations were complicated by numerous large stones in the soil.

As a result, during the measurements on Aug. 3, the probe showed the depth of bedding of the mountain rock debris rather than the real thawing depth.

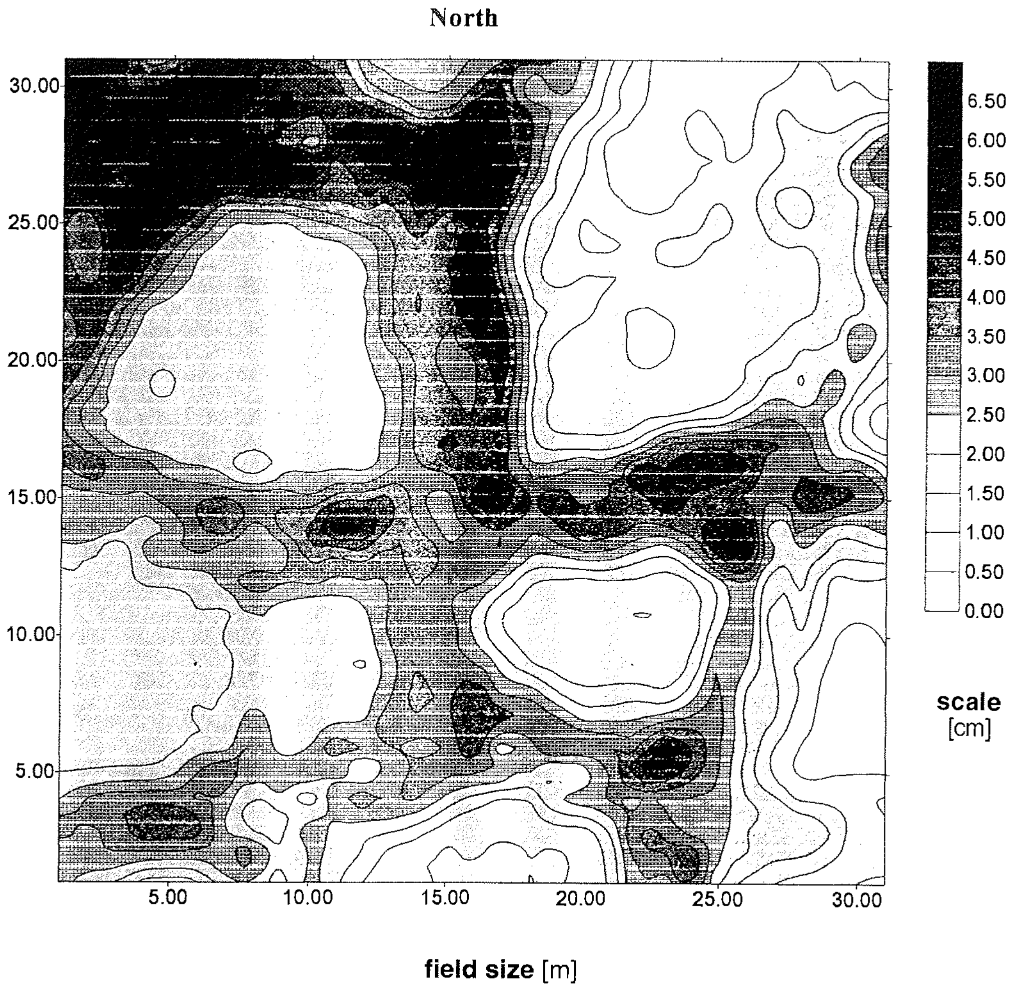


Figure 2-28: Microrelief of measuring field for determination of active layer depths (for location see Fig. 2-24).

Also, six short profiles from the firns under the relic north of the camp were set up. Three profiles were located under the slope of the southern exposition and three under the slope of the northern exposition. At these profiles single measurements of soil temperature were made.

They have shown some dependence of the thawing depth on the location of the water flows along the firns. Similar typical features were also observed when analyzing the data obtained in other regions of the Arctic.

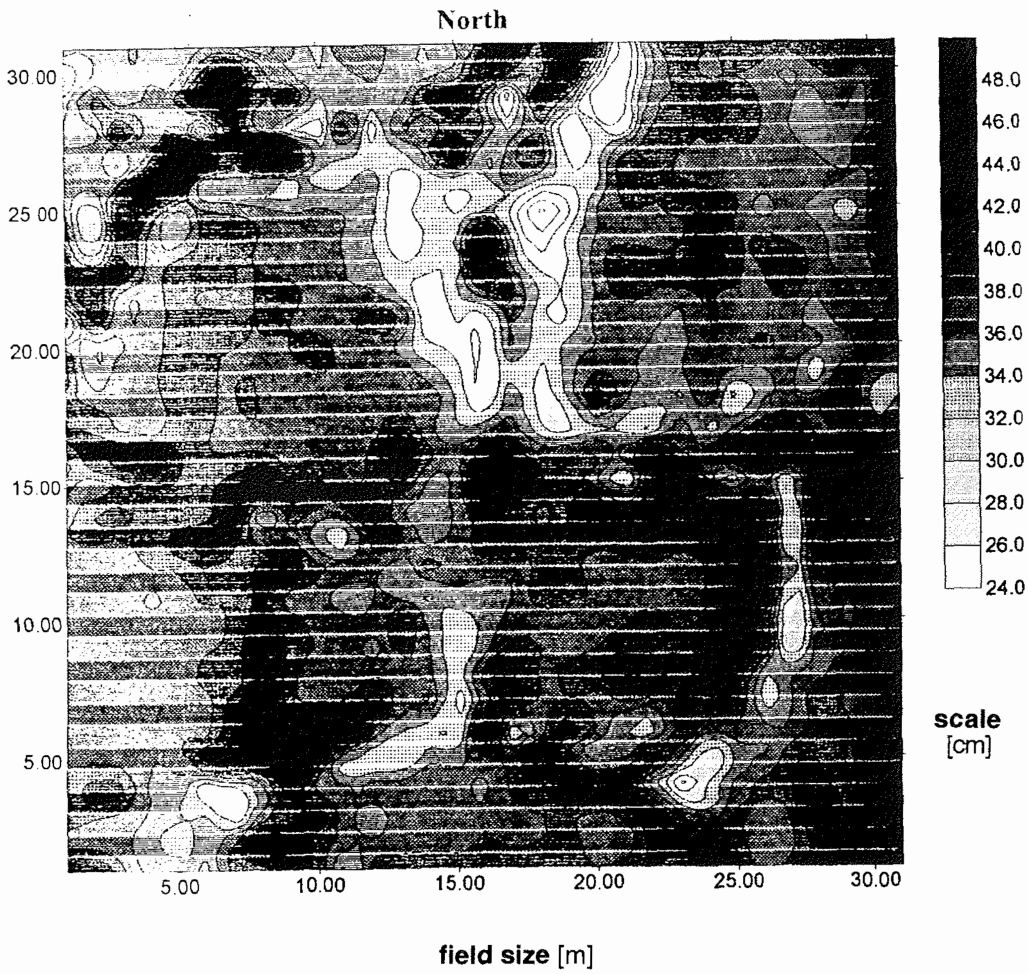


Figure 2-29: Active layer depths in the measuring field at Aug. 18, 1995 (scale is in cm, field size in m, for location see see Fig. 2-24).

2.3.2 Hydrological Processes in the Active Layer
(B. Hagedorn, J. Boike, T. Ebel, T. Meinel)

Studies on the hydrology and energy balance of the active layer in the Levinson-Lessing Lake catchment started in 1994 and are summarized in detail in Boike et al. (1995) and Boike et al. (1996). In 1996, as in the previous year(s), one automatic climate and soil moisture/soil temperature recording station was erected on the calcareous slope (Fig. 2-22). This site was still covered with snow of up to 30 cm thickness. Profiles of volumetric moisture content and temperature were recorded in 8 depths within the soil profile.

The climate station recorded relative humidity, air temperature, wind speed and direction, rainfall, and netradiation. These data will be used to calculate vertical heat and water fluxes in the active layer during the seasonally thawing. Manual readings of soil temperature and moisture were undertaken once a week at sites on slope 1, 2, and 3 in the entire catchment (Fig. 2-22). At the end of the field period, the soil pits were excavated and all instruments removed.

2.3.3 Hydrology and Suspension Transport in the Krasnaya River

(D. Gintz, T. Meinel)

Methods

Over a period of about two months, hydrological parameters and suspended sediment transport values were measured at a selected cross profile of the Krasnaya River. The measurements of various parameters started in June (19.06.96) and ended in the middle of August (13.08.96). The following parameters were observed:

- discharge (water level, water velocity),
- electric conductivity,
- water temperature,
- pH-values, and
- turbidity and suspended sediment transport.

Measurement of water discharge. - Due to the persisting snow and ice-cover of the riverbed it was not possible to install the gauging station before the first of July. In the late afternoon of the same day, the main flood wave initiated by snowmelt occurred (see Fig. 2-30). The location of the gauging station was the same as in the previous year, about 500 meter above the river delta at the Levinson-Lessing Lake. The discharge was calculated by use of the automatic water level record (Ott) and correspondent flow velocity measurements (Ott-propeller).

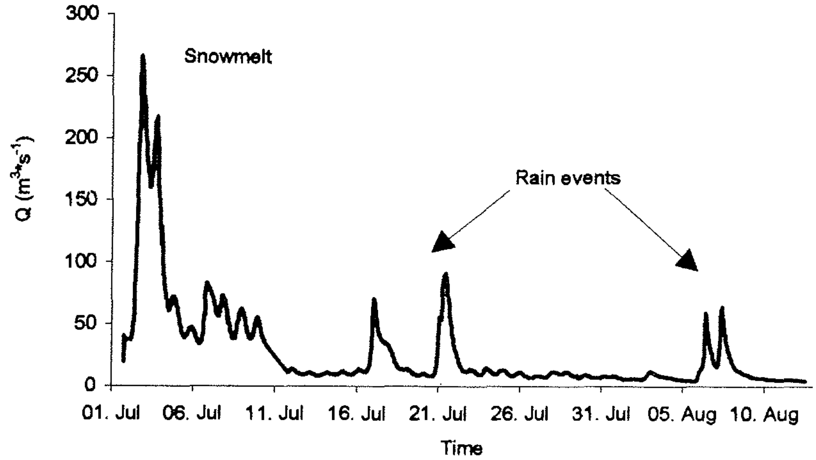


Figure 2-30: Hydrograph of Krasnaya River in summer 1996.

Measurements of electric conductivity, turbidity, water temperature and pH-values. - The measuring station was equipped with probes for electric conduc-tivity, turbidity (HACH Backwash Turbidimeter), temperature, and pH-values. The Backwash Turbidimeter is a continuous flow absorptometer, which meas-ures the amount of light transmitted through the sample related to the suspen-ded sediment concentration. These data were continuously measured from June 19 to August 13, 1996, in one second time-intervals and the minutes average values were logged. The probes were installed in the first main can-nel on a rope, spanned perpendicular to the flow direction. The energy supply for this equipment was provided by two solar-panels and two "dryfit"- batteries.

Suspended sediment sampling. - To calibrate the HACH Backwash transmission signals with the suspended sediment concentration it was necessary to collect water samples. Up to four one liter samples (10, 25, 35 and 62 cm above ground) were simultaneously collected in one vertical profile with a multiple point-sampler from a boat. In addition, at high water levels the two other small channels were also sampled. The collected water samples were filtered with cellulose acetate (CAF) filters with a pore size of 0.45 µm which were air-dried afterwards.

Preliminary Results

Water level, water velocity, discharge. - In the first weeks (until July 16, 1996) of water level recordings the daily oscillations were generated by snowmelt. The maximum value of the first discharge peak was about 266 m^3s^{-1} exceeding bankfull discharge (see Fig. 2-30). The subsequent moderate daily flood waves reached their maximum values around midnight, and lowest levels about noon time. The following discrete peaks after the snowmelt period were caused by different rain events.

Electric conductivity, dissolved load, pH-values, and water temperature. - The values of electric conductivity in the Krasnaya River vary in a range from 19 to 63 µS. Owing to the dilution effect of high discharge, the expected inverse correlation between electric conductivity and discharge could be observed (see Fig. 2-31). In general, there is an increasing trend of the dissolved concentration up to the end of the observed time interval. To calculate the dissolved load it was necessary to classify discharge categories. Then the product of dissolved amount and discharge class was summarized. For the observed period of 55 days the calculated total amount of dissolved load was 2500 t, in average 45 t/d. In a very short time of only three days, 75% of the total dissolved load was transported.

The pH-values oscillated around pH 7, and ranged between pH 6.4 to 7.8. The water temperature varied in a daily rhythm, with lowest temperatures in the early morning hours. Daily warm up of water temperature was about 5 to 6 degrees Celsius. In general, the daily average temperature increased from 0.0 °C to 11 °C up to the beginning of August (02.08.96). After this period the average temperature values decreased rapidly.

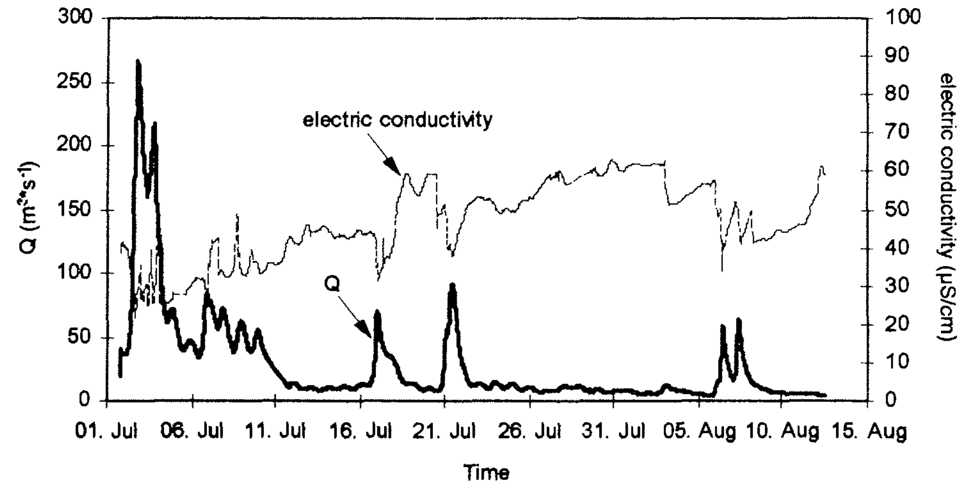


Figure 2-31: Hydrograph and electric conductivity of Krasnaya River in summer 1996.

Turbidity and suspended sediment concentration. - With the HATCH Back-wash Turbidimeter it was possible to measure the variable turbidity over different floodstage on-line (Fig. 2-32). At low water levels with small dischar-ges a noise up to 15 % transmission values was observed (100 - 85 %). With an in-crease of discharge the transmission values decreased in the same way. At the falling limb of the flood wave the transmission values increased more ra-pidly then the discharge. Nevertheless, there is a good correlation (R^2 = 0.85) between discharge and turbidity values. The values decline most at low and high discharges. This can be explained with the noise at low discharges and the different behavior of the concentration of suspended sediments in the course of the rising and falling limb of a flood wave (hsyteresis effect).

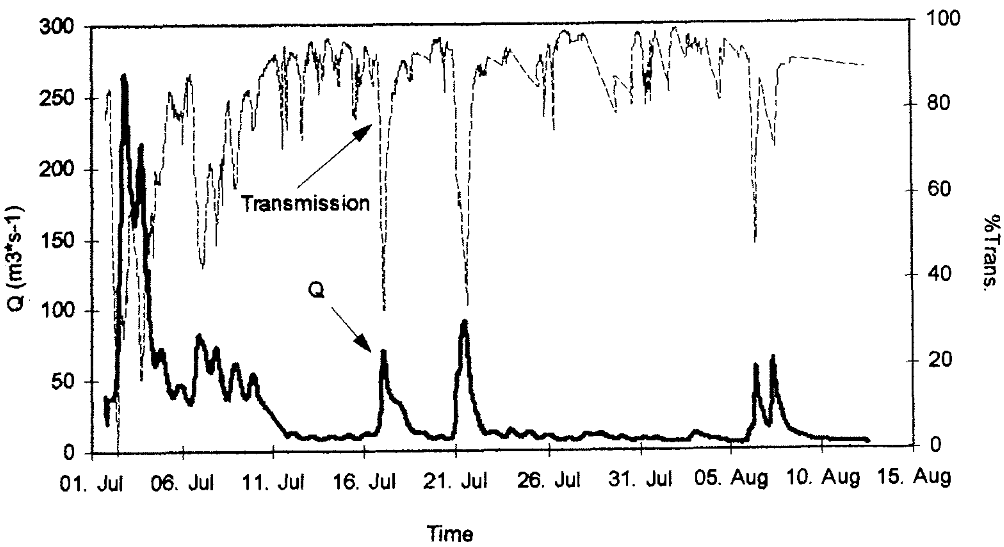


Figure 2-32: Hydrograph and % of transmission of Krasnaya River in summer 1996.

The correlation between turbidity values and the sediment concentration samples is week (R^2 = 0.72), but in general the sediment concentration decreases with increasing transmission values.

The amount of the total suspended sediment load for the measuring time interval of 55 days is 21000 t. The amount of 75 % of the total suspended sediment load was transported in only two days.

2.3.4 Hydrology of Surface Waters and of Levinson-Lessing Lake

(B. Hagedorn, T. Ebel, T. Meinel)

The hydrological setting of the lake is an important parameter for the biological activity in the water column. Also the sedimentation processes were influenced from the physical and geochemical behavior of the water body. The lake has a mean surface area of 22 km^2 and a mean depth of 68 m.

Methods

During the field work in summer 1996, the following parameters and investigations were carried out on lake water, stream inflows, soil water, and precipitation (rain/snow):

- recording of temperature, oxygen , pH and electrical conductivity, and
- anion measurements (F^-, Cl^-, NO_3^-, PO_4^- and SO_4^{2-}).

Furthermore, water samples of 60 ml were taken for

- stable isotope measurements (^{18}O, ^2H), and
- cation measurement (Ca, Mg, Na, K, Sr, Ba).

The parameters: t (°C), electrical conductivity (mS/cm), pH and O_2 (mg/l) in the lake water were recorded *insitu* with a VARIO 5PT (ELBAGU) instrument connected with a 100 m cable. Registration was performed with an integrated datalogger. The pH- and O_2-sensors were calibrated with pH-reference solutions of 4.01, 7.00, 10.00 and with air, saturated with water vapor, respectively. The pH and electrical conductivity measurements of surface waters were car-ried out with WTW instruments in the camp.

The measurements of anions were carried out in the field with an IC 2001 Ion-chromatograph (EPPENDORF company) on pure water samples using the suppression method (suppression column BT-S-AG-P). The anions were separated with a BT-X-AN-S resin column by rinsing with an EKXAN-CO3 / EKXAN-HCO3 eluent. Before injection, the samples were filtered with a 0.45 mm CAF filter. The calibration was performed with two reference solutions of 1 ppm and 10 ppm for Cl^-, NO_3^-, PO_4^{2-}, SO_4^{2-} and 0.2 ppm and 2 ppm for F^-. The concentrations were calculated from the chromatogram using the "WIN-PEAK" software (EPPENDORF).

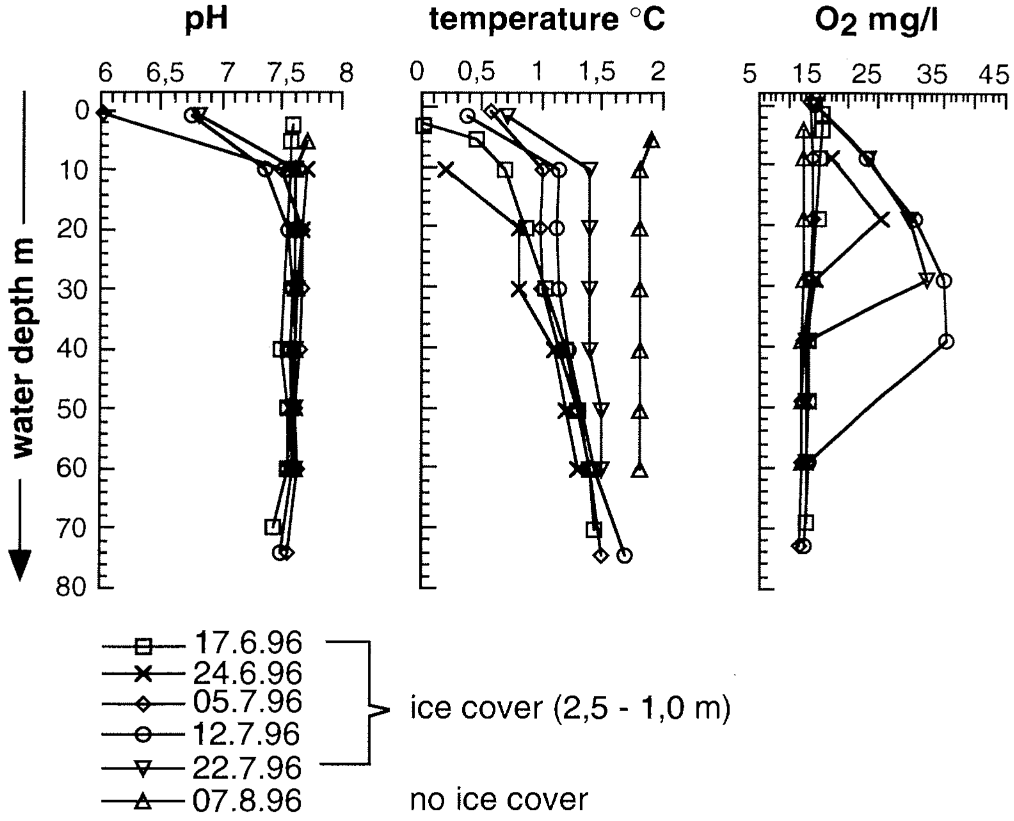


Figure 2-33: Seasonal records of pH-values, temperature, and oxygen content in the lake water body.

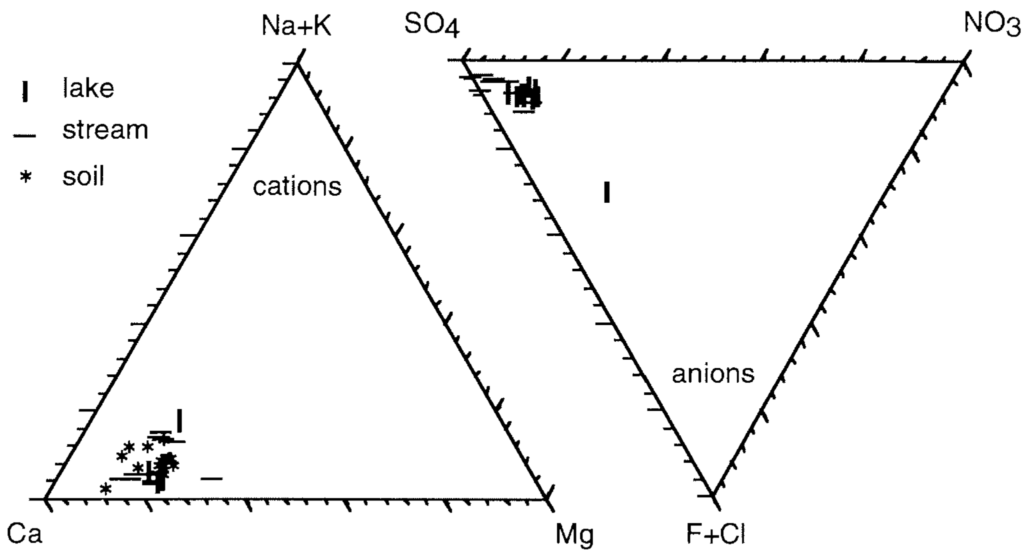


Figure 2-34: Cation and anion compositions of lake, stream, and soil water within the Levinson-Lessing Lake and its catchment area.

At the beginning of the field work, the lake was covered by 2.5 m ice. The ice cover became unstable at July 22 and was completely thawn at August 8, 1996. Figure 2-33 show the hydrochemical and -physical variations of the water column during spring and summer. Under the ice cover the O_2 content have a strong peak in 10 m to 40 m water depth. The pH and electrical conductivity doesn't change with water depth and time. Under the ice cover the temperature increase from water surface (water / ice interface) to the lake bottom. The Lake reach maximum temperatures of 2°C in the middle of August.

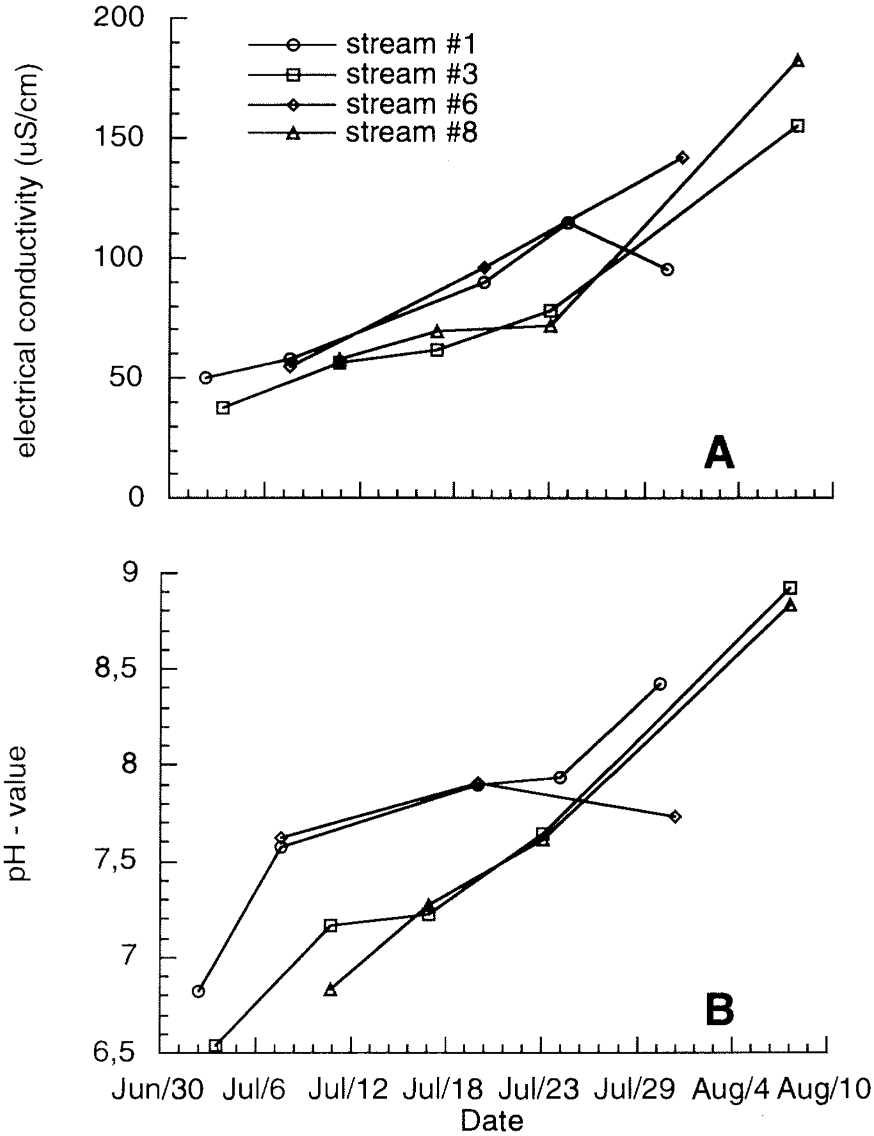


Figure 2-35: Seasonal variations of electrical conductivity (A) and pH-values (B) of the stream inflows.

The total concentration of solutes in the lake water is low (about 40 mg/l). The main cations are Ca (5-8 ppm) and Mg (1-2 ppm) and the main anion is SO_4^{2-} (1- 4 ppm). The chemical composition of anions and cations is shown in Figure 2-34.

The chemical composition of the stream inflows is equal to the lake water, whereas the amount of solutes shows a strong seasonal variation with an increase from July to August from 50 mS/cm to 190 mS/cm and pH 6 to pH 9 (Fig. 2-35).

2.3.5 Modern Sedimentation in Levinson-Lessing Lake

(B. Hagedorn, T. Ebel, T. Meinel)

The investigations of sedimentation processes in the Levinson-Lessing Lake have started in 1995 and were continued in 1996. The study of recent sedimentation in the Levinson-Lessing Lake together with the river discharge regime and hydrology of the active layer may enable us to determine the influence of weather conditions on sediment mobilization in the catchment area and sediment accumulation in the lake basin.

For this objective trap experiments, suspended load of lake water and stream inflows, as well as "surface cores" (30 cm coring depth) are investigated applying geochemical, radiochemical and mineralogical methods.

Methods

The recordings of sedimentation rates were carried out with sediment trap-chains installed in three water depths on five locations (Fig. 2-36). To determine the suspended matter in the water column at these locations, 5 l of lake water were continuously sampled and filtered.

A detailed description of the methods is given in Hagedorn et al. (1996). After the onset of snowmelt sediment load of five small stream inflows were sampled continuously (Fig. 2-22).

First Results

At the beginning of the field period in 1996 the lake was covered by 2.5 m thick ice and up to 1 m snow. At this time the stream inflows and the active layer were still frozen. The suspended matter in the water column was below 0.01 mg l^{-1} and the sedimentation rates ranged between 0.01 mg cm^{-2} d^{-1} and 0.06 mg cm^{-2} d^{-1}.

During snowmelt (July 1 to 5) the sedimentation rate increased by one to two orders of magnitude (Table 2-7), with highest sediment load the sediment traps close to the lake bottom. The suspended matter in the water column increases to 0.1 to 10 mg l^{-1} .

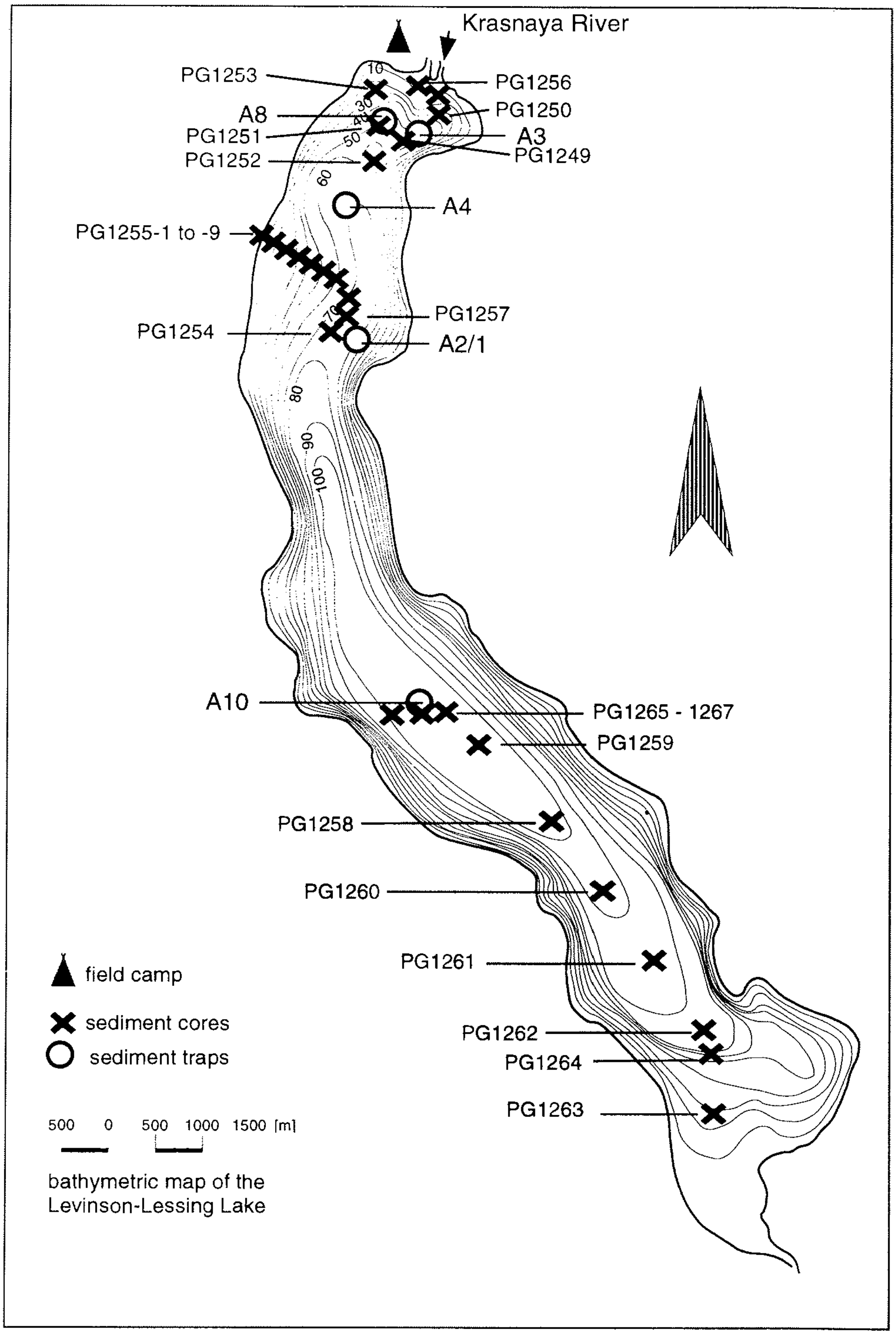


Figure 2-36: Bathymetric map of the Levinson Lessing Lake and sampling sites of surface cores (x) and sediment traps (o).

Table 2-8: Results of the sediment trap experiments in the northern part of the Levinson-Levinson Lake.

trap no.	latitude / longitude [N / E]	water depth [m]	trap depth [m]	date of sampling 1996 in	out	sediment content [g]	sedimentation rate [mg/cm^2/d]
A3	74°31'86"	50	23	21.6.	27.6.	0.0238	0.060
	98°36'37"		38	21.6.	27.6.	0.0154	0.039
			48	21.6.	27.6.	0.0174	0.044
			23	27.6.	5.7.	0.1764	0.332
			38	27.6.	5.7.	0.7733	1.454
			48	27.6.	5.7.	1.2168	2.287
			23	5.7.	10.7.	0.1061	0.319
			38	5.7.	10.7.	0.2656	0.799
			48	5.7.	10.7.	0.5037	1.515
			23	10.7.	22.7.	0.1101	0.138
			38	10.7.	22.7.	0.5842	0.732
			48	10.7.	22.7.	2.1208	2.658
A2/1	74°31'31"	70	28	19.6.	26.6.	0.0353	0.076
	98°35'71"		48	19.6.	26.6.	0.0330	0.071
			68	19.6.	26.6.	0.0156	0.034
			28	26.6.	1.7.	0.0033	0.010
			48	26.6.	1.7.	0.0046	0.014
			68	26.6.	1.7.	0.0068	0.020
			28	1.7.	7.7.	0.0146	0.031
			48	1.7.	7.7.	0.0778	0.167
			68	1.7.	7.7.	0.0770	0.165
			28	7.7.	12.7.	0.0658	0.198
			48	7.7.	12.7.	0.1263	0.380
			68	7.7.	12.7.	0.3913	1.177
			28	12.7.	22.7.	0.0807	0.121
			48	12.7.	22.7.	0.2085	0.314
			68	12.7.	22.7.	0.3305	0.497
A8	74°31'83"	57	29	24.6.	5.7.	0.2803	0.383
	98°36'09"		44	24.6.	5.7.	1.3173	1.801
			55	24.6.	5.7.	2.1390	2.924
			29	5.7.	10.7.	0.1964	0.591
			44	5.7.	10.7.	0.2729	1.094
			55	5.7.	10.7.	0.6697	2.684
			29	10.7.	22.7.	0.2087	0.262
			44	10.7.	22.7.	0.1075	1.683
			55	10.7.	22.7.	0.3406	3.526
			29	22.7.	3.8.		
			44	22.7.	3.8.	0.1310	0.164
			55	22.7.	3.8.		
			29	3.8.	10.8.	0.2772	0.595
			44	3.8.	10.8.	0.3962	0.851
			55	3.8.	10.8.	0.0337	1.798
A4	74°31'32"	65	27	28.6.	5.7.	0.1074	0.231
	98°35'67"		47	28.6.	5.7.	0.2862	0.615
			67	28.6.	5.7.	0.0999	0.215

Continuation next page

Table 2-8: Continuation

trap no.	latitude / longitude [N / E]	water depth [m]	trap depth [m]	date of sampling 1996 in	out	sediment content [g]	sedimentation rate [mg/cm^2/d]
			27	5.7.	10.7.	0.1459	0.439
			47	5.7.	10.7.	0.4631	1.393
			67	5.7.	10.7.	0.9420	2.833
			27	10.7.	3.8.	0.2047	0.128
			47	10.7.	3.8.	0.0868	0.054
			67	10.7.	3.8.	0.2014	0.126
			27	3.8.	7.8.	0.1346	0.506
			47	3.8.	7.8.	0.1556	0.585
			67	3.8.	7.8.	0.3484	1.310
A10	74°28'30" 98°38'12"	108	55	6.7.	22.7.	0.0413	0.039
			75	6.7.	22.7.	0.2543	0.239
			105	6.7.	22.7.	0.1378	0.130

2.3.6 Methane Biogeochemistry in Levinson-Lessing Lake
(V.A. Samarkin)

Introduction

Tundra lakes are an important but poorly studied natural source of atmospheric methane. The methane budget in lakes is controlled by its microbial production in bottom sediments, its oxydation in sediments and in the water column, and its emission to the atmosphere by diffusion and ebullution. Migration of methane from the deep, CH_4 rich lake sediments to the surface can also have influence on its budget. In August 1996 investigations were conducted in order to receive recognition on the peculiarities of methane biogeochemistry in Levinson-Lessing lake.

Methods

Depth profiles of CH_4 concentrations in the sediments. - In order to determine CH_4 concentrations in the sediments two cores of 30 cm lenth were taken from a boat near sampling site PG1253 (see Fig. 2-36) using a gravity corer ('Schwerelot'). Immediately after recovery, cores were closed by rubber stoppers and transported to the camp laboratory within 0.5 hour.

Sediment samples of 30 ml in volume were taken from each 4 cm thick core interval and transferred into 150 ml glass jar containing 40 ml of saturated NaCl solution. The jars were immediately closed with screw cups equipped with rubber discs, and shaken vigorously by hand for 3 min in order to suspend sediments. Subsequently, they were equilibrated for 2 hours before gas fase analyzes. Gas samples for analyzes were drown through rubber disc by 1 ml gas tight syringe. CH_4 concentrations were determined in the field using a portable gas chromatograph XPM-4 (Chromatograph Co., Russia) with flame ionization detector and 2 m long stainless steelcolumn filled with Poropack Q resin.

Methane flux measurements. - Methane flux from the lake to the atmosphere was measured in the area of its active ebullution observed in a distance of 50 m from the shore in front of the camp (J. Boike, pers. comm. 1996). The water depth at the site was 9.5 m. A gas trap was constructed in the field and installed in the lake. The system consisted of (1) a pyramidal aluminium trap covering an area of 0.75 m^2 with a copper tube of 7 mm outside diameter in the top of the piramide connected with rubber box to collect gas, (2) a rubber box, (3) two porous plastic floats, (4) an anchor of 15 kg weight, and (5) a rope of 5 mm outside diameter (see Fig. 2-37).

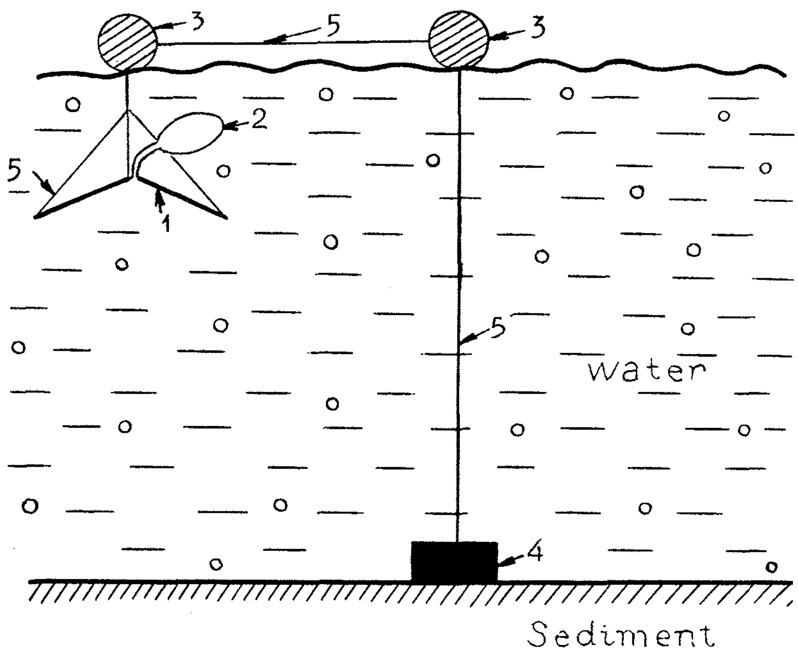


Figure 2-37: Schematic illustration of the gas trap.

The system provides the possibility to collect gas bubbles permanently from the place of location and to change the trap location according to the wind direction. The gas fromthe rubber box was transferred once a day to glass bottles and analyzed for CH_4 concentrations within 1 hour. The methane flux was calculated on the basis of the quantity of gas trapped, the CH_4 concentrations in the gas, the surface covered by the trap, and the exposure time.

Determination of methane generation rate. - Methane generation rates were measured in 4 cm thick sediment pieces down to a depth of 32 cm using ^{14}C bicarbonate and ^{14}C acetate which are the main precursors of biogenic methane. The details of the technique are described in Chapter 2.2.4.2.

Results and Discussion

The depth profile of CH_4 concentrations in the sediments is presented in the Figure 2-38. Almost linear increase of CH_4 concentrations indicate that diffusion from the deep is the main factor controlling methane distribution in the sediment core studied.

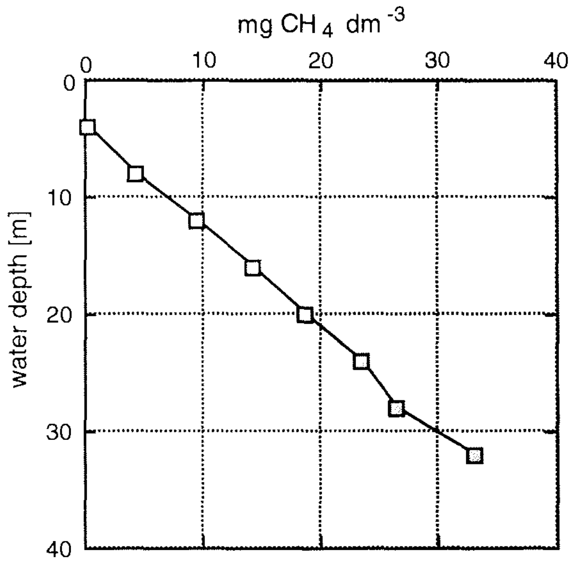


Fig. 2-38: Depth profile of CH_4 concentrations in lake sediments.

The process of methane generation was detected from both ^{14}C substrates used. In the top 16 cm methane generation via CO_2/H_2 reduction was nearly twice as large as that from acetate, whilst in deeper horizons both processes had similar rates. In the sediment core studied 60% of methane was produced from CO_2/H_2 and 40% from acetate as a whole.

Table 2-9: Methane generation rate in lake sediments.

sediment depth [cm]	methane generation rate	
	$\mu g\ C/CH_4 \cdot dm^{-3} \cdot d^{-1}$ from CO_2/H_2	$\mu g\ C/CH_4 \cdot dm^{-3} \cdot d^{-1}$ from acetate
0 - 4	0.1	0.04
4 - 8	0.6	0.3
8 - 12	1.6	0.7
12 - 16	1.9	1.0
16 - 20	1.5	1.5
20 - 24	0.7	0.8
24 - 28	0.5	0.6
28 - 32	0.2	0.2
mean	0.9	0.6

Methane flux from the lake sediments was determined within five days. It varied from 1014.0 to 1214.3, mean 1130.5 mg $CH_4 \cdot m^{-2} \cdot d^{-1}$. In the area of active gas ebullition the surface sediments were sandy gravel and only methane migration from the deep could ensure as large CH_4 flux as measured. Sediment layers rich in methane were detected in a 22.3 m long sediment core (PG1228) recovered in summer 1995 (T. Ebel, pers. comm. 1996), and by shallow seismic profiling carried out in 1996 (see Chapter 2.4) . The stable isotope composition of carbon and hydrogen in the methane was measured in order to determine its origin. The value of $\delta^{13}C$ was -70.0 ppm, that of δD -282 ppm. It suggests that the methane is of biogenic origin and has been formed mainly by CO_2/H_2 reduction (Sugimoto & Wada, 1993, 1995).

Conclusion

From these preliminary data it is possible to conclude that Levinson-Lessing lake sediments have accumulated a large amount of biogenic methane. The transport of methane through the sediment water interface is solely by molecular diffusion in the deep part of the lake. In this area it is consumed in surface sediments and in the water column by methanotrophic bacteria and probably does not release to the atmosphere. In littoral areas near Krasnaya river delta, biogenic methane produced and stored in deep sediment layers migrate to the sediment surface and to the water column essentially by ebullution and can produce extremely high CH_4 flux to the atmosphere. It demonstrates the importance of near-shore sediments of tundra lakes as natural sources of atmospheric methane.

2.4 Sub-bottom Profiling in Levinson-Lessing and Taymyr Lakes

(F. Niessen, C. Kopsch, T. Ebel, G.B. Federov)

2.4.1 Objectives

Sediments in lakes mostly consist of muds and are thus penetrable with high-resolution seismic pulses operating in the frequency band between 1 and 15 kHz. The objectives of sub-bottom profiling in lake basins on the Taymyr Peninsula during the expedition in 1996 was three fold:

(1) Profiling across previous coring locations can provide two- or three-dimensional information about the depositional situation of the two long cores which were obtained from the lakes in 1995 (Overduin et al. 1996). This can be used to better interpret core data and can also help to select additional future coring sites.

(2) Sub-bottom reflector geometry can help to characterise the changes of sedimentary environments in space and time on a basin-wide scale. This can then be used to interpret which sediments may be relicts of previous glaciations (e.g. consolidated by grounded ice), and which may represent non-glacial suspension deposits.

(3) Seismic stratigraphy can indicate the total thickness of the undisturbed post-glacial fill of the lacustrine basins. Since none of the cores retrieved in 1995 reached bedrock or basal moraine, seismic stratigraphy can give hints of the basal age of the fill and thus the possible timing of the last glacial excavation of the basins.

The area is of particular interest for palaeoclimatic research because there is an ongoing debate concerning the extent and chronology of glaciations in Central Siberia during Weichselian time. For the last glacial maximum reconstructions range from small isolated ice caps over the archipelagos of the Eurasian shelf and ice-free conditions over the Taymyr Peninsula to a large ice-sheet of more than 2,500 m thickness which covered the entire Siberian shelf and extended far into continental Eurasia.

2.4.2 Methodology

A "Chirp" sediment echo sounder was used as high-frequency pulse source (GeoChirp 6100A, Geoacoustics, UK). The system is portable and has a total weight of about 150 kg. It consists of four parts: Transducers, "Chirp Electronics Bottle" (Chirp generator and amplifier hardware), Chirp Transceiver and Chart Recorder (Ultra Electronics, Model 3710). The heaviest parts, the 4 transducers and the "Electronics Bottle", are towed in a small catamaran 20 cm below the water level. The system was modified by the AWI (see Fig. 2-39) by combining it with a digital delay box (connected to the Chirp Transceiver), a GPS receiver (Trimble Scoutmaster, for positioning) and a four-channel DAT-tape recorder (Sony PC 204A, for data storage of seismic trigger, seismic signal and GPS position). All delicate instruments were placed in a water-proof compact aluminium box with a transparent lid. We have operated the entire system from a small inflatable boat (3.6 m length) using a 15 HP outboard engine. A 1000 W Generator was used as energy source.

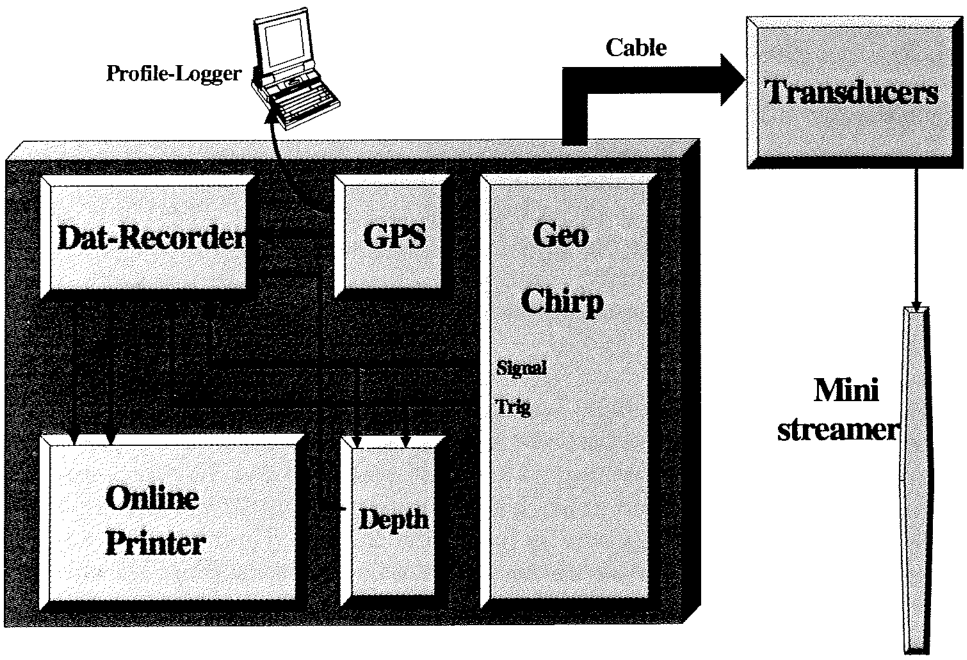


Fig. 2-39: Scheme of modified sub-bottom profiling system.

The principle of the chirp sonar is somewhat similar to that of "Vibroseis". A sweep of different frequencies is transmitted over a short period of time. The GeoChirp system offers the choice of two different modes: pulses of 2 to 8 kHz for deeper penetration and of 1.5 to 11.5 kHz for higher resolution. On Lake Taymyr we only used the high-resolution mode. For both modes, the sweep length is 32 ms. The output power is 400 W. Reflections are measured using a "mini-streamer" of 6 hydrophones sensitive in a band width between 0.5 to 15 kHz. The streamer is pulled 70 cm behind the catamaran. The returning sweep of signals is processed in the Chirp Transceiver over a period of 130 ms during which a cross correlation of the received echo pulses is carried out. The transmission trigger rate was set to 4 "chirps" per second. For operation in deeper water, the processing procedure can be delayed by digital steps of 10 ms using the delay box. We have printed the processed signals on the chart recorder in analog mode. These prints are used for presentation in this report. Post-processing is possible using the trigger and the processed signal which were stored on the DAT-tape recorder. Previous results of GeoChirp profiling in Greenland lakes recorded during the Polarstern expedition ARK-X/2 are presented in Niessen & Melles (1995) and Hubberten et al. (1995)

GPS positioning was optimised by combining the Trimble data output on the lakes with GPS data received by a reference station on land (GPS-DAN linked to a power book by PCMCIA-port). Data sampling rate and storage was 2 sec for both systems. Since this combination does not provide exact differential GPS data, a post processing was carried out at the Institut für Geodäsie der Universität Dresden. The accuracy was improved from +/- 500 m (unprocessed) to +/- 10 m (processed).

2.4.3 Field Work

Taymyr Lake. - Lake Taymyr is the largest water body on the Taymyr Peninsula. From west to east the lake is more than 200 km long and mostly between 10 and 20 km wide. It is subdivided into several sub-basins. Approximately 70% of the lake area has a water depth of less than 3 m. Therefore, seismic studies were to be carried out only in the central part of the lake (Fig. 2-40) where the water depth can be more than 20 m. A map of the Lake Taymyr area and the bathymetry of the central part of the lake are presented in Overduin et al. (1996).

On 18 July one helicopter flight was used to transport the scientific party from Kathanga to the camp at Levinson-Lessing Lake. The seismic equipment was flown in earlier at the beginning of the first period of the Taymyr expedition. Because of the ice situation at Levinson-Lessing (about 95% ice cover) it was immediately decided to proceed by helicopter to Lake Taymyr of which the ice situation was expected to be better for seismic profiling. Four scientists, the seismic and camp equipment plus two barrels of fuel arrived in the evening of 18 July in the central area of Lake Taymyr. The camp location, which was not changed during the campaign, is shown in Figure 2-41.

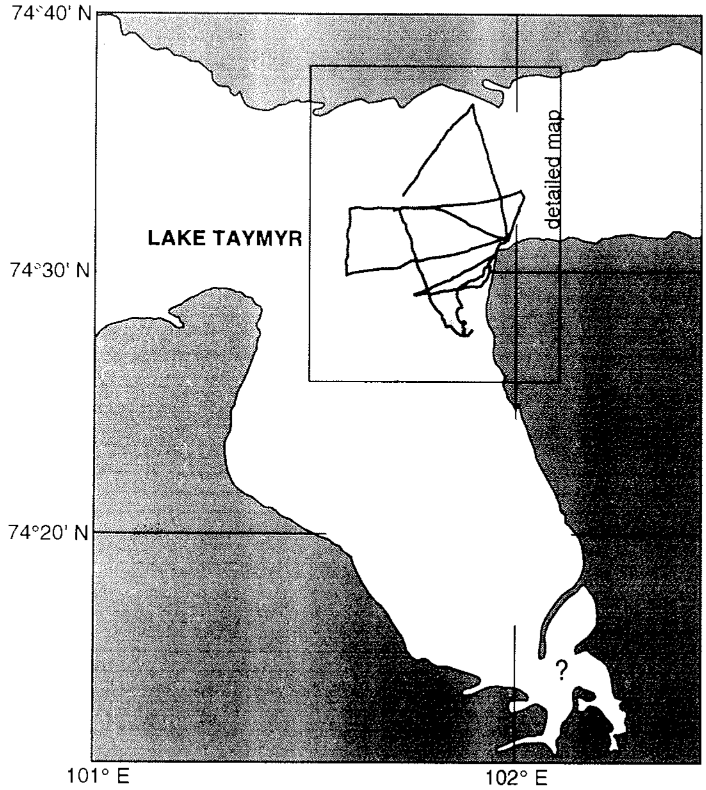


Figure 2-40: Central part of Lake Taymyr. Location of GeoChirp seismic track lines 1-11.5 kHz. The gray-shaded areas mark the ice cover of the lake as observed from the helicopter on 18 July 1996 (darker gray) and on the 8 Aug. 1996 (light gray). The ice situation in the most southerly part of the lake was not seen.

Unfortunately, the ice cover of the lake as well as stormy weather allowed seismic profiling only during a few days (30 July to 3 Aug.) of the total time spent at Lake Taymyr. At the time of arrival, the entire working area in the central and southern part of the lake was covered by lake ice which still had a thickness of about 80 to 100 cm (Fig. 2-40). The northern part of the working area became first ice free on 28 July. In the southern part of the lake, a nearly complete ice cover remained until the end of the Lake Taymyr campaign (8 Aug., Fig. 2-40). Nonetheless, a total of 11 high-resolution profiles (1 to 11.5 kHz, length: 103.2 km) were recorded during the expedition of which three profiles (3, 4, and 8) crossed the coring location (PG1227) of the expedition in 1995 (Fig. 2-41). The wiggles in the track lines of the most southerly profiles 4 and 5 (Fig. 2-41) were caused by the ice situation. Two large ice flows prevented profiling along a straight course line and did not allow to proceed further to the south.

There are two observations which are of interest for the interpretation of the sedimentary record. (i) The lake is affected by relatively rapid lake level

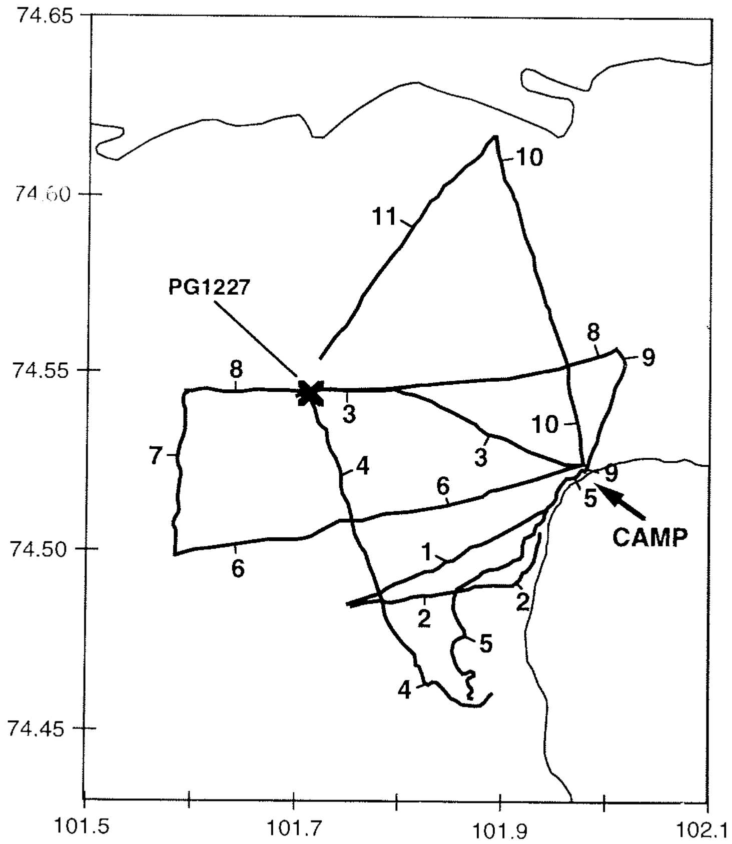


Figure 2-41: Detailed map of seismic track lines in the central Taymyr Lake and locations of the camp and coring site (PG1227 retrieved in 1995).

changes. During the time spent in the camp the level rose between 20 and 27 July by ca. 33 cm and dropped between 26 July and 7 Aug. by ca. 70 cm. (ii) During periods with stormy weather and relatively high waves on the lake, the lake water about east of the camp became turbid over a large area indicating erosion and probably lateral transportation of fine grained suspension.

Levinson-Lessing Lake - Levinson-Lessing is situated in the southern Byrranga Mountains and drains through the Ledyanaya River into Lake Taymyr. The lake is about 15 km long and mostly between 1 and 1.5 km wide. The maximum water depth is 108 m in the central part of the lake (Fig. 2-42). Numerous streams drain into the lake which form small fan systems. The largest river Krasnaya enters the lake from the north where a relatively large fan system has been built up. The northern part of the lake valley as well as some of the adjacent valleys are characterised by typical U-shaped morphologies suggesting a glacial origin or overprint.

On 8 August the scientific party and equipment was transported by one helicopter flight from the camp site at Taymyr Lake to the base camp at Levinson-Lessing. About two days later, Levinson-Lessing became completely ice free.

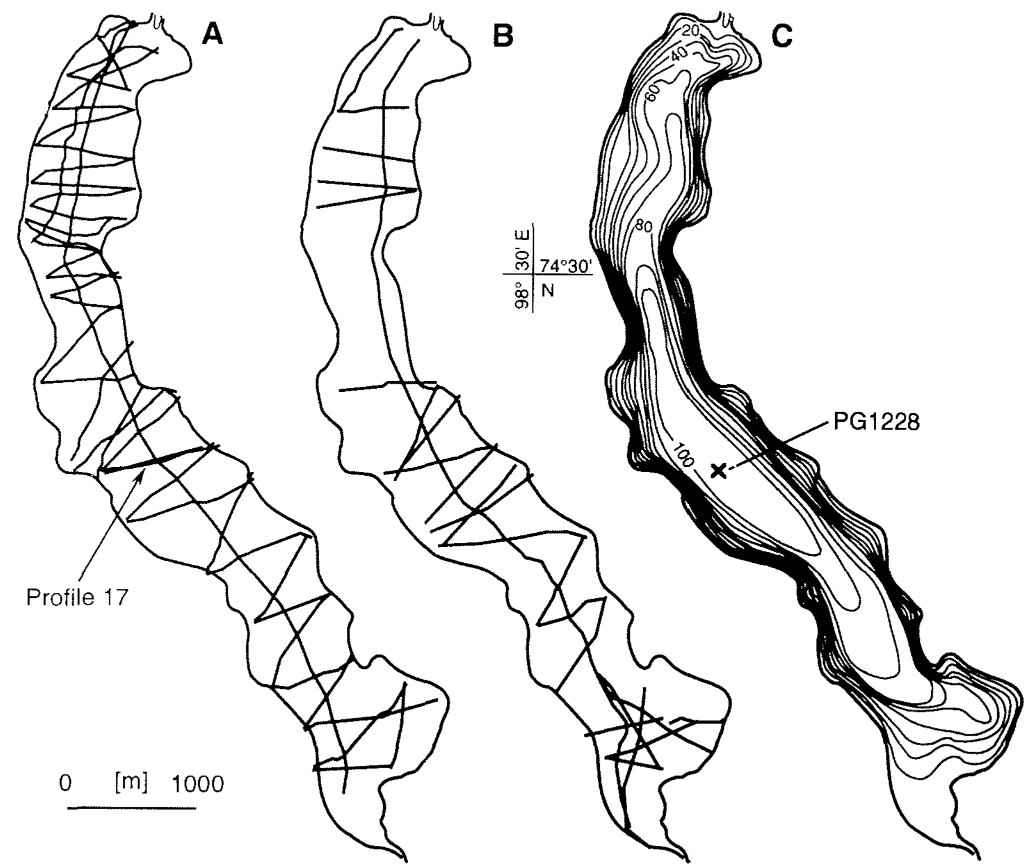


Figure 2-42: Lake Levinson Lessing. GeoChirp track lines of high-resolution (A) and high penetration (B), as well as bathymetry and coring location of PG1228 (C). The geographical coordinates refer to map C. Some of the track lines cross the shore line of the lake. This is because the corrected GPS positions were not to match the outline of the lake taken from a Russian map.

After 9 August a total number of 42 profiles (ca. 59.1 km) and 24 profiles (ca. 38.3 km) were recorded in the high-resolution and high-penetration modes, respectively (Fig. 2-42). In total, five profiles crossed the location of the coring site PG1228 of the expedition in 1995. Lines profiled in high-penetration mode were selected on the basis of the high-resolution results. The field work ended on 16 August when the party returned by helicopter to Khatanga.

2.4.4 Preliminary Results

Taymyr Lake - In 30 m deep Lake Taymyr sound penetration is observed to a sediment depth of maximal 25 m. The sediments are well stratified and, in places, show prograding geometries from shallow to deeper water (10 m to >20 m). Two major seismic units can be distinguished. The boundary between the units is defined by truncation of strata in the lower unit and may be caused by lake level changes. Thicknesses of up to 20 m and 14 m are observed in the upper and lower units, respectively. The lower unit can only be seen in shallow water because a strong reflector at or near the base of the upper unit prevents deeper sound penetration in the central part of the basin.

The profile presented in Figure 2-43 is characteristic for the deeper part of the central lake basin where a maximum water depth of 31 m was measured (using 1420 m/s as sound velocity in water). The sequence only represents the upper seismic unit down to the strong reflector between 40 and 50 m below lake level. The dark grey shading below 50 m is the first reflection multiple of the lake floor. The reflector geometry of the sediment fill suggests significantly higher sedimentation rates in deeper water. This suggests that sediment focusing effects into the central basin is important for the deposition of the upper unit. The backscatter characteristic is somewhat diffuse as indicated by high-amplitude reflections from the topmost layers and strong lateral variation of both appearance and strength of reflection horizons in the deeper part of the section.

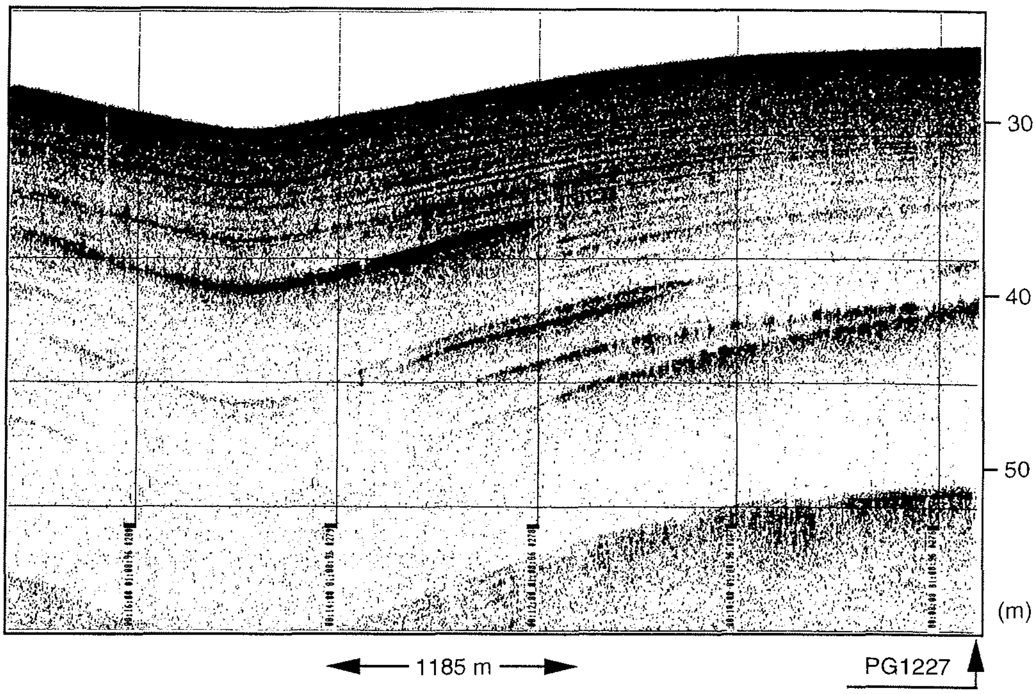


Figure 2-43: Example of a GeoChirp profile (northern end of profile 4) across the coring location of PG1227. The grid line distance is 10 ms. The depth scale was calculated assuming a constant Vp of 1420 m/s.

The sequence was cored in 1995 (Fig. 2-43). The relatively uniform sediments consist of clay and silt. In the lowermost part of the core an unsorted mixture of sand, silt and clay was found which is possibly associated with alluvial deposition (Overduin et al. 1996). These sediments probably form the lowermost strong reflector at the coring site (Fig. 2-43). The entire core is rich in gas which led the sediments expand by 1 to 1.5 % after recovery (Overduin et al. 1996). The high content of sedimentary gas can explain the diffuse character of the backscatter. In particular rapid lateral shifts in penetration and sub-bottom resolution (as observed in the profile) can often be associated with gas bubbles in the sediments. Dating of the sediment core is under way and will allow an assessment of the ages of the different seismic units.

Levinson Lessing Lake. - In Lake Levinson-Lessing maximum sound penetration was observed to sediment depths of about 60 m.The relative uniform, well-stratified sediment fill thins towards the southern end of the lake so that a strong basal reflector (bedrock or moraine) becomes visible if the sediment fill is less than 40 m thick. Above the basal reflector there are three seismic units. The relatively thin bottom unit can only be seen in deeper water. The top unit is distinguished from the middle unit by onlaps in shallow water. There is a decrease in penetration depth towards the northern end of the lake. Near the Krasnaya River fan, the penetration is nearly zero indicating a relatively strong influence of riverine sediment input to the northern part of the lake and, subsequently, the acoustic behaviour of the deposits. Sediment analysis will show whether the decrease of penetration is related to an increase of grain size and/or sedimentary gas.

The profile presented in Figure 2-44 is characteristic for the "plain" in the central and deepest part of the lake. Well stratified reflectors are seen of which the upper 9 m show a stronger backscatter. Below about 20 m sub-bottom another set of stronger reflectors is found which prevents deeper sound penetration in the presented area (high-resolution mode profiles). The backscatter character-istic of these deeper reflectors is slightly diffuse and thus somewhat similar to the reflectors in Lake Taymyr as described above.

Two features observed in the profile are indicative for the depositional environment. (i) At the left end of the profile, between 3 and 8 m sub-bottom, there is a small lenticular sediment body showing diffuse backscatter which can be interpreted as a slump deposit. It is the only slump deposit seen in the entire profile. In general, slump deposits are rare in the central and southern part of the lake which indicates that, depite the relatively steep slopes, redeposition is not common in Levinson-Lessing. (ii) There is a horst-like feature in the mid-dle of the profile of which the origin remains obscure. Sediments, however, drape this structure so that, although slightly levelled, its morphology is still seen on the lake floor. This suggests deposition from suspension by which settling from "pelagic rain" is probably more prominent than deposition from turbidity flows. In general, the uniform character of the well stratified basin fill suggests relatively stable sedimentary conditions during the history of Lake Levinson-Lessing.

A 22.3 m long core taken in the central part of the basin penetrated down to the base of the upper unit (Fig. 2-44). This core represents less than half of the entire fill at the coring location as seen in the long south-north profile and the high-penetration profile across the coring location. The basal age of this core is probably mid to early Weichselian (Hahne pers. comm. 1997) which implies an even older age of the lower part of the sediment fill. It is suggested that the entire stratified sediment fill of the lake basin was deposited during times when the lake basin was not glaciated.

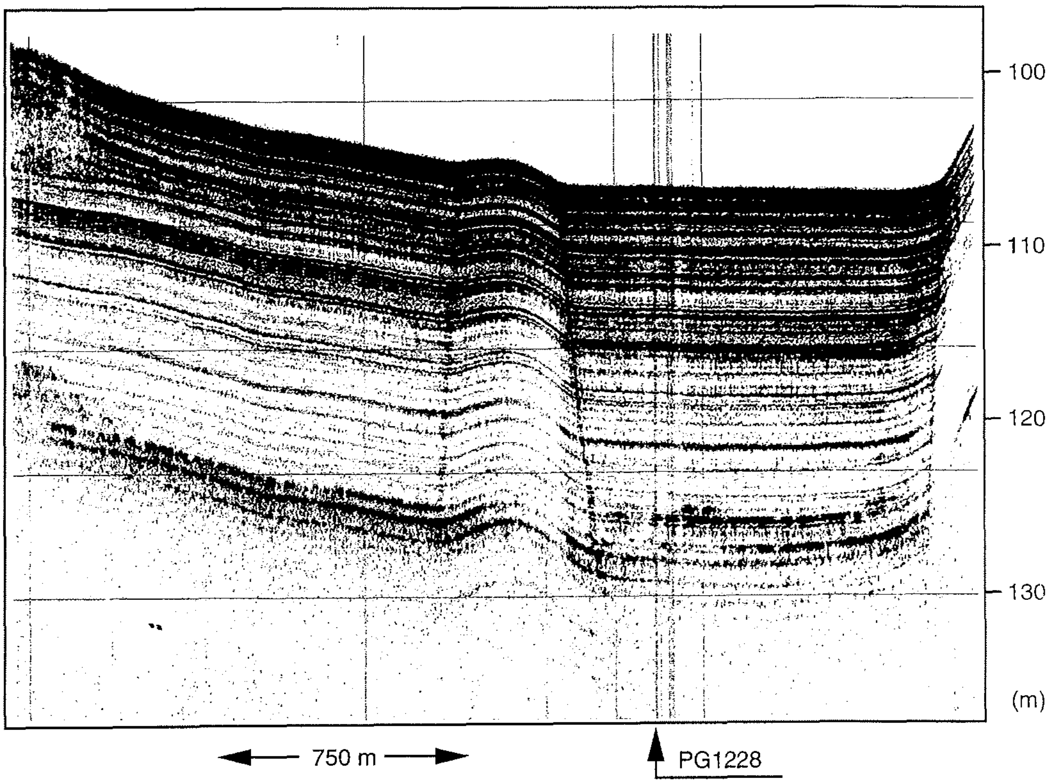


Figure 2-44: Example of a GeoChirp profile across the coring location of PG1228 (central part of profile 17). The grid line distance is 10 ms. The depth scale was calculated assuming a constant Vp of 1420 m/s.

According to pollen analysis (Hahne pers. comm. 1997) the Late Pleistocene to Holocene transition is between 9 and 7 m core depth. This suggests that the increase of reflection strength observed in the seismic profile at 9 m is probab-ly related to a change in the depositional environment caused by climatic change. It is interesting to note that at the depth of the lower stronger reflector an interstadial was found in the sediment core as indicated by pollen results (Hahne pers. comm. 1997). Since the backscatter characteristic (Fig. 2-44) is similar to that observed in Lake Taymyr (Fig. 2-43), the lower Levinson-Les-sing reflectors may also be associated with an increased gas content in the sediments. This may be caused by a higher input of organic matter to the lake during interstadial periods.

2.5 Studies of Late Quaternary Sediments and Geocryology

2.5.1 Introduction

(P. Møller, D. Yu. Bolshiyanov, A. Dereviagin, G. Carlemalm)

There is no debate on the question *if* the Taymyr Peninsula has been glaciated; the questions are, however, *when* and *from which spreading areas*. There is a maximalistic view and a minimalistic view concerning glacial coverage of Siberia during the Weichselian and, in particular, the Late Weichselian, very well summarized by Rutter (1995). These questions will be approached in this report.

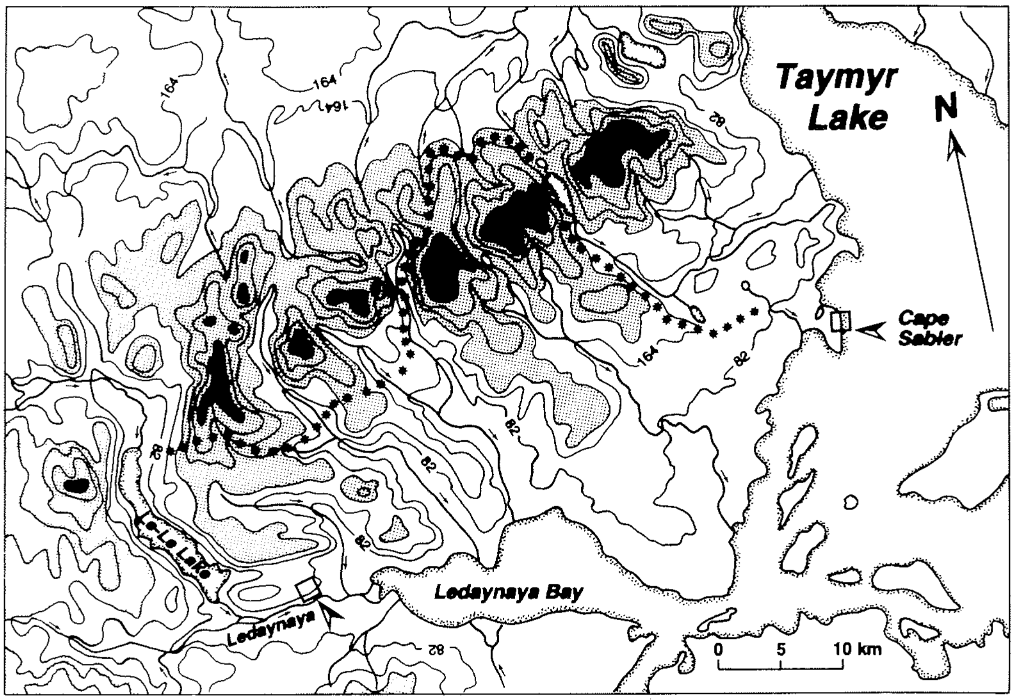


Figure 2-45: Map of the northwestern part of the Taymyr Lake and the central Byrranga Mountains. Contour interval is 250 feet / 82 m. White area above lake level <250 m a.s.l.; shaded areas = 250-500 m a.s.l.; black areas >500 m a.s.l. The Cape Sabler and Ledyanaya sites are marked by box and arrow. The reconnaissance route through the mountains, from Cape Sabler to Levinson-Lessing Lake, is marked by small stars.

A few words on terminology of the glacial chronology should be useful. The following is used in the Russian literature, here given with European equivalents:

- Upper Zyryansk (Sartan) stadial; ca. 22-10 ka. Equivalent to the Late Weichselian
- Karginsk interstadial; ca. 55-22 ka. Approximately equivalent to the Middle Weichselian.
- Lower Zyryansk stadial; ca. 110-55 ka. Equivalent to the Early Weichselian.
- Kazantzevo interglacial; >110 ka. Equivalent to the Eemian.

- Bakhtan glacial. Equivalent to the Saalian.

The field work in the 1996 season was carried out in three different areas (see Fig. 2-45):

- *The central Byrranga Mountains.* Geomorphological reconnaissance from Cape Sabler (western Taymyr Lake) to Levinson-Lessing Lake.
- *The Ledyanaya River.* Sedimentological and stratigraphical investigations of deltaic sediments west of Ledyanaya Bay, Taymyr Lake.
- *Cape Sabler.* Sedimentological, stratigraphical, and geocryological investigations of fine-grained sediment and ground ice in the Cape Sabler sections, western Taymyr Lake.

Brief descriptions of sites and the field work and some preliminary interpretations are given below.

2.5.2 Sedimentological and Stratigraphical Studies

(P. Møller, D. Yu. Bolshiyanov, G. Carlemalm)

2.5.2.1 Reconnaissance Tour in the Byrranga Mountains

A reconnaissance tour of ca. 100 km was carried out along the Byrranga Mountains, from Cape Sabler to the Levinson-Lessing Lake (see Fig. 2-45 for itinerary). The route covered parts of six valleys cut into the mountains; two on the northern side of the watershed and four on the southern side. The purpose of the reconnaissance was to get a first-hand impression of the mountain geomorphology. Kind & Leonov (1982), for example, did describe the cross-Byrranga valleys as glacial troughs and noted areas of distinct glacial erosion and areas of dead-ice morphology along the mountain range.

Observations. - Our own observations can be summarized as follows:

- The Permian shales and sandstones are usually deep-weathered, when not exposed in gorges.
- Dolerite dykes, striking more or less parallel to the mountains and thus often forming cross-valley riegels, are more weathering-resistant and less deep-weathered; they often form series of high tors along the valley slopes.
- Tributary valleys are V-shaped in cross-section and show zigzag patterns, often ending in large (still active) alluvial fans which are feeding the valley braid-plains.
- Glacial cirques were not observed.
- Glacial abrasion was not observed (and not expected, due to high frost-shattering activity).
- Glacial depositional landforms seem nonexistent.
- Very few exotic boulders (erratics) were observed.
- Terraces of sand and gravel (erosion remnants) occur along valley sides, with top surfaces at 100-120 m a.s.l. These are interpreted as marine deltas (see the Ledyanaya locality below), deposited at a regional marine level ca. 100 m above the present. No till or exotic boulders were observed on top of the delta surfaces.

Bedrock samples were collected for surface-exposure datings, based on AMS measurements on *in situ* accumulation of cosmogenic isotopes such as ^{10}Be, ^{36}Cl, ^{3}He and ^{26}Al. These analyses are in progress.

Preliminary interpretations and palaeoenvironmental implications. - The Byrranga Mountain landscape has a morphology very much governed by the activity of weathering-, slope- and fluvial processes, but not of glacial processes. The tors and the deep-weathered bedrock are of substantial age, i.e. most probably not the result of weathering during Holocene time only. If they should have been overridden by an Upper Zyryansk ice sheet, that must have been persistently cold-based for these elements to survive. As for the Taymyr Lake basin, the existence of an ice sheet of this age is rejected by the continuous lacustrine/terrestrial sedimentation record from the Cape Sabler sections. It is thus our opinion that the Byrranga Mountains, at least on their central part, was not glaciated during the Upper Zyryansk, and that a substantial time has passed since the last glaciation of the area. This is further supported by the deltaic sequences without till or erratics on top - deltas which may be associated with a high marine level during a Bakhtan (Saalian) or Lower Zyryansk (Early Weichselian) deglaciation (see below).

2.5.2.2 The Ledyanaya Marine Sections

The Ledyanaya is an east-flowing river, originating in the Byrranga Mountains. It forms a wide braidplain in the Ledyanaya valley and enters the Taymyr Lake in its westernmost part (in Ledyanaya Bay; Fig. 2-45). Approximately 6 km upstream from its mouth (at 74°25´ N; 99° E) there is a huge accumulation of sand and gravel, ca. 4 km in length and 1 km wide (Fig. 2-46), rising to nearly 100 m above the river bed. The sediments are buttressed towards a dolerite ridge in the west and spread out towards the northeast, east and south. They form two very flat terraces at ca. 115 m a.s.l. in the western part and a more hummocky deposit in the northeast. The highest parts in the latter area are, however, in level with the main terraces. Small terraces of sorted sediments are also found on the mountain slope north of this area. This suggests the former existence of a flat-topped and coherent deposit measuring at least 3x4 km, today much reduced due to a combination of solifluction and fluvial erosion and with the initial surface only preserved in the west. The internal composition of this deposit could be studied at four different sites (1-4, Fig. 2-46).

Sediment descriptions. - The main sections were found along the Ledyanaya river, which is actively eroding the terrace sediments, forming a ca. 300 m long and up to 25 m high bluff. The coarser facies of the sediments were highly susceptible to failure following excavation, so it was not possible to get a continuous record. Three sections in the western part of the bluff was excavated and logged, covering an altitudinal range of 24.5-44 m a.s.l., with three gaps ranging between 0.5 to 3.3 m in hight.

A 5.5 m high sediment succession in the westernmost part of the bluff (*Ledyanaya 1a*; Figs. 2-46 and 2-47) starts with interbedded massive silt and mas-

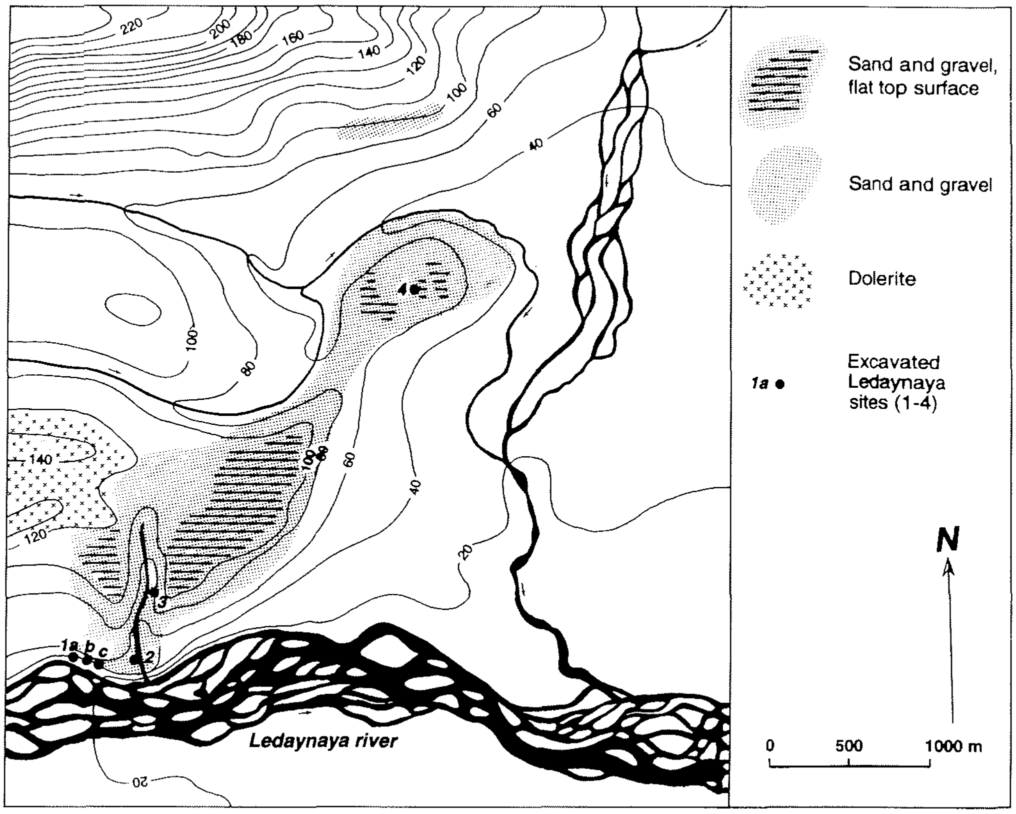


Figure 2-46: Map of the Ledyanaya area, showing the distribution of deltaic deposits and the position of excavated sites.

sive and planar parallel-laminated fine sand, all beds dipping 6-10° towards SW (220°). The silt beds abound in mostly paired *in situ* mollusc shells, especially *Astarte borealis.* The succession coarsens upwards into predominantly massive and planar parallel-laminated sand and gravelly sand, interbedded by occasional beds and bedsets of massive silt and fine sand. The silt beds usually contain paired *Astarte borealis* shells. Some massive sand beds have out-sized (MPS 7-11 cm) clasts, showing a-axis orientation parallel to flow and an up-flow imbrication (*a(i)a(p)* fabric).

Further to the east (*Ledyanaya 1b*; Figs. 2-46 and 2-48) the sediment succession steepens, forming foresets dipping 25-30° towards ca. 275°. Predominating foreset facies is medium massive sand with a varying content of pebbles and often disc-shaped cobbles (MPS of individual beds 6-15 cm). The latter clasts usually show a beautifully developed *a(i)a(p)* fabric. The coarse foresets are occasionally interbedded with massive silty sand and silt, the latter beds with *in situ* molluscs (*Astarte borealis, Hiatella arctica*) and sand-infilled burrows.

Ledyanaya 1c (Fig. 2-46; no log presented here) shows a 9 m high (34.8-44 m a.s.l.) succession of foreset-bedded sand and gravel, dipping 28-32° towards 260-275°. Predominating facies are beds of massive sand and gravelly sand,

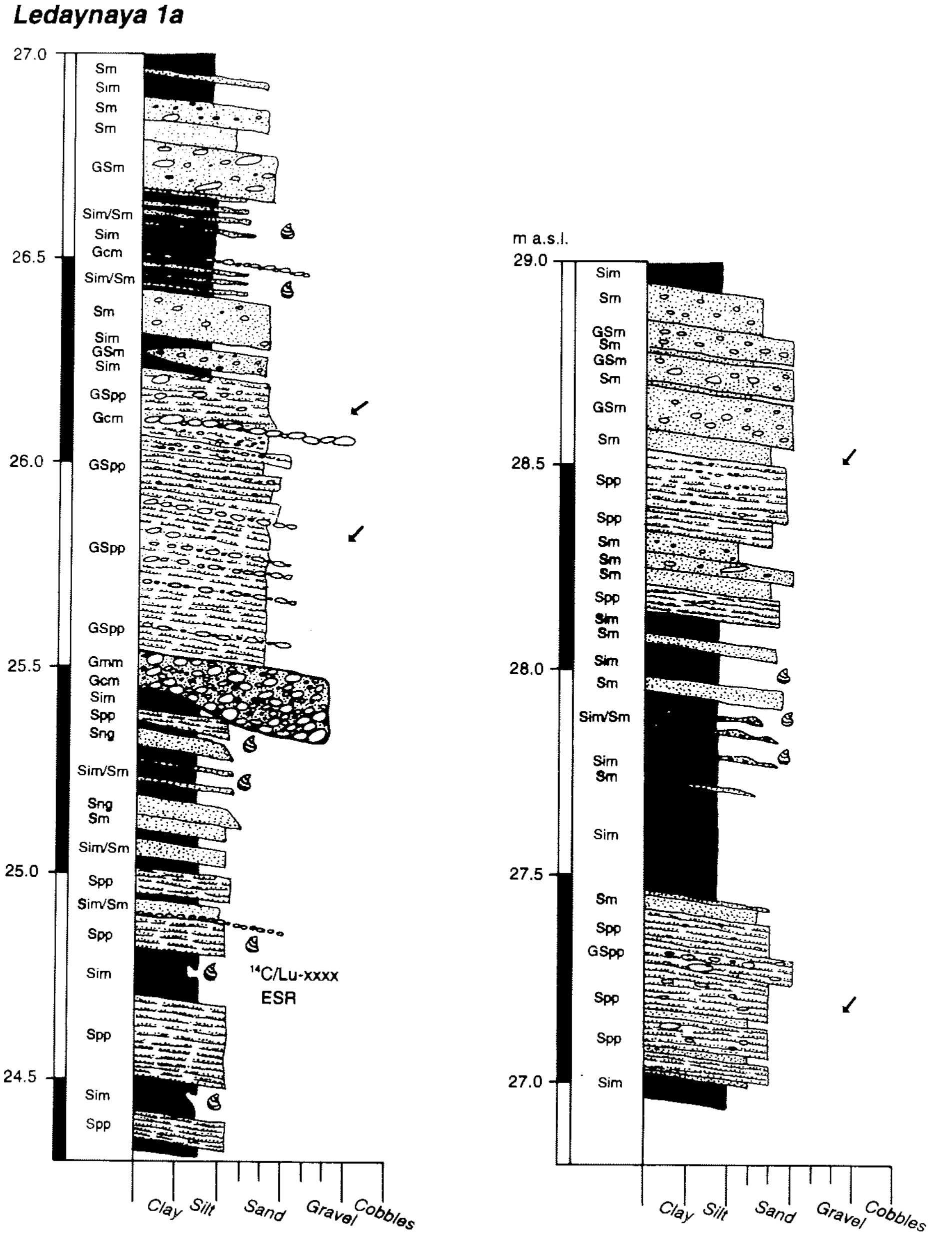


Figure 2-47: Sediment log from the Ledyanaya delta, section 1a. Lithofacies codes (also in Figs. 2-48 and 2-49): *Sim*, massive silt; *Sm*, massive sand; *Spp*, planar paral-lel-laminated sand; *Sng*, normally graded sand; *GS*, gravelly sand; *Gcm*, clast-suppor-ted massive gravel; *Gcng*, clast-supported normally graded gravel; *Gcig*, clast-suppor-ted inversely graded gravel; *Gmm*, matrix-supported massive gravel; *Co*, cobble. Dip directions of foresets are indicated by small arrows. Positions of *in situ* mollusc shells are also indicated.

clast-supported gravel/cobble beds and normally graded beds, starting with clast-supported coarse gravel and cobbles at their base and grading upwards into massive sand. There is a pronounced *a(i)a(p)* fabric in many beds. Minor

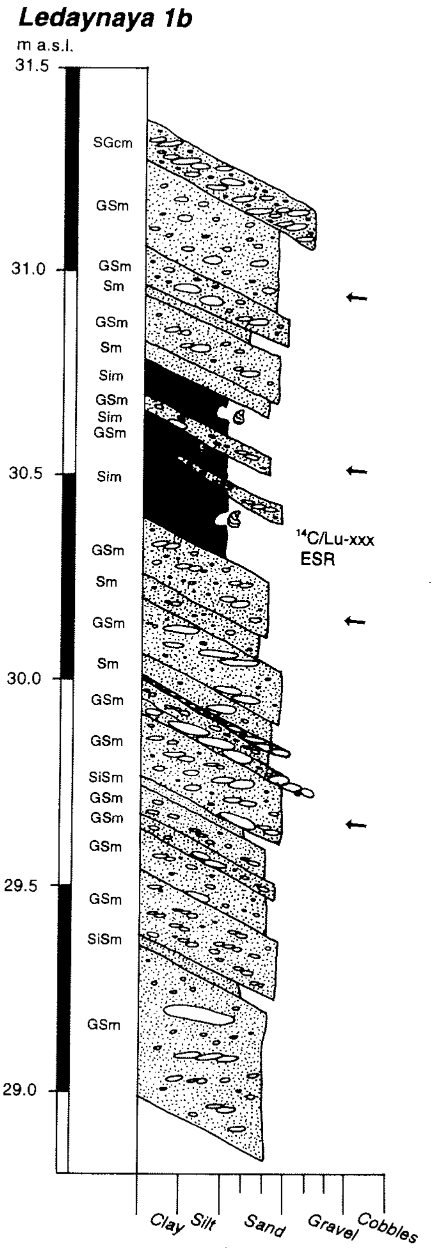


Figure 2-48: Sediment log from the Ledyanaya delta, section 1b. For lithofacies codes, see Fig. 2-47.

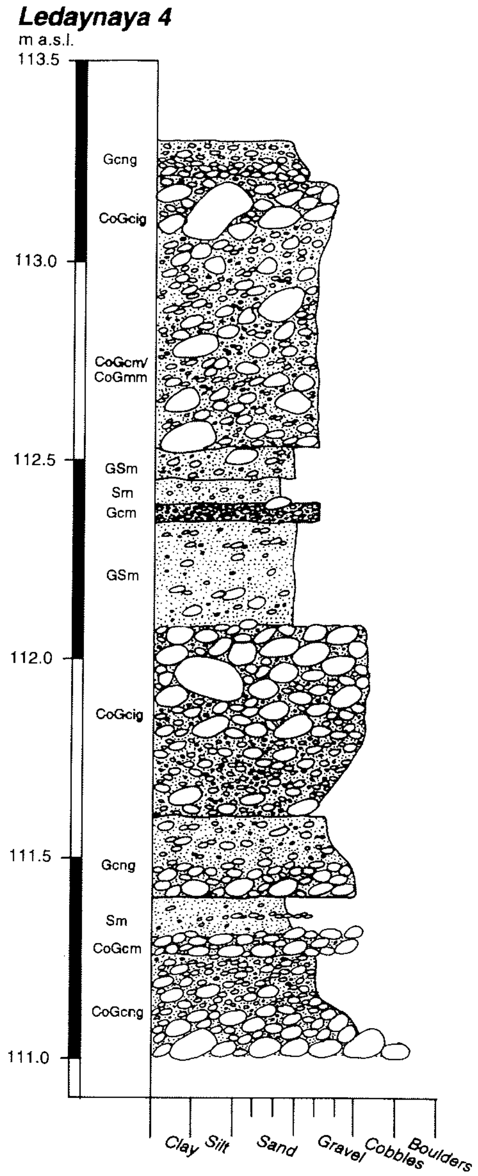


Figure 4-49: Sediment log from the Ledyanaya delta, section 4. For lithofacies codes, see Fig. 2-47.

facies constituents are thin beds of massive silty sand and silt, the silt often penetrating the upper part of the framework of underlying coarse beds. At places the silt is present just as a framework infilling. Some silt beds carry both fragmented and paired *Mya truncata* and *Hiatella arctica* shells.

Ledyanaya 2 (Fig. 2-46; no log presented here) is a 3.5 m high succession of sediments, deposited in a stream gully cut into the Ledyanaya sands and gravels. The sediment succession shows clast-supported gravel beds and massive sand beds, frequently interbedded with massive silt and beds of organic material. Datings on these valley infill sediments should give a minimum age of the Ledyanaya sands and gravels.

Ledyanaya 3 (Fig. 2-46; no log presented here) is a 3.5 high succession (65.5-69 m a.s.l.) of foreset-bedded sand and gravel, dipping 10-18° towards 200-225°. The succession is predominated by very well-sorted and thinly planar parallel-laminated sand, occasionally with some out-sized glider and roller clasts. The succession also showed some erosional scours with cobble and gravel infilling and some erosional cobble and gravel lags. No molluscs was found.

Ledyanaya 4 is situated in the northeastern dissected part of the deposit (Fig. 2-46). Some erosion remnants are in level with the main terraces. Below one of these top surfaces (114.5 m a.s.l.) it was possible to excavate a 2.3 m high succession (Fig. 2-49) of very coarse sediments in primary position. Sediments further down-slope was considered to be soliflucted and not in primary position. The primary section shows a horizontally stacked sequence of clast-supported normally graded and inversely graded cobble/gravel beds, interbedded with thinner massive sand and fine gravel beds. MPS within the logged beds is 16 cm, but boulders with diameters up to 50 cm were found during the excavation work.

AMS ^{14}C-datings, ESR-datings (Electro Spin Resonance) and aminoacid analyses on molluscs samples are in progress, like AMS ^{14}C-datings on organic sediments from the Ledyanaya 2 section. Finegrained sediment samples will also be analysed on diatom and foraminiferal content.

Preliminary interpretations and palaeoenvironmental implications. - The Ledyanaya sands and gravels are a deltaic sequence, deposited in a marine environment with a water level around 100 m above the present sea level. The Ledyanaya 1b, 1c and 3 sections represent mid-delta foreset facies, deposited from sediment gravity flows along deltaic lobes prograding towards a southwest-directed sector (200-275°). The predominating facies states indicate that high-density, sandy-gravelly turbidity currents and debris flows were dominant in transporting sediment down-slope. Direct suspension sedimentation from fully turbulent flows is shown by the normally graded gravel beds. However, the usually very distinct fabric suggests that, even if sedimentation was from suspension, clast interaction with development of dispersive pressures was an active process during the late stage of final deposition. The logged succession at Ledyanaya 3 is less gravelly and suggests mainly traction deposition from grain-flows and with incorporation of coarse outrunners and sliding clasts. Interbedded silts occur surprisingly high in the foreset sequences, indicating shifting current directions and the possibility for suspension settlement of these finegrained sediments. These shifts must have been stable for some time as molluscs obviously had time to migrate into the sediment.

The Ledyanaya 1a section represents more fine-grained lower-delta foreset facies, deposited from more distal sediment gravity flows, interfingering with bottomset marine muds. This section is altitudinally below the Ledyanaya 1b-c sections, but was actually deposited in a stratigraphically higher position, on/overlapping the foreset sequence at section 1b. This also demonstrates the directional shifts of the delta lobes and successive progradation of the delta in different directions.

The Ledyanaya 4 succession is interpreted as part of a topset bed and thus representing the feeder system of the delta, probably forming a braid-plain environment. The logged sequence represents coarse bar sediments, showing vertical accretion during both rising and falling stages (CoGcng/CoGcig).

Unfortunately the contact between topset and foreset beds could not be located. This surface should represent the actual water level better than the top surface of the delta. It can thus only be concluded that the water level of the marine episode reached somewhere between 69 and 110 m above present sea level. However, at Ledyanaya 3, foresets impossible to excavate due to repeated failures continue at least 10-20 m upwards, so a marine level around 100 m a.s.l. is quite likely.

At present we have very vague indications on the age of this high-level marine episode that seems to be regionally important along the northern fringe of the Taymyr Lake. As stated earlier, similar deposits (though not sedimentologically investigated) are frequent in many Byrranga Mountain valleys, which open up towards the Taymyr Lake basin. The only available date so far is an ESR one on a mollusc shell from the Ledyanaya site, yielding 100 000 ± 8500 B.P. (Bolshiyanov, unpublished). As the mollusc assemblage (*Astarte borealis, Mya truncata, Hiatella arctica*) does not represent a boreal, warmer than present Kazantzevo/Eemian interglacial fauna, we can so far only conclude that the Ledyanaya delta sequence is of unknown, but old, age. It may represent a high marine stage following either a Bakhtan (Saalian) or a Lower Zyryansk (Early Weichselian) deglaciation of the area. The Ledyanaya sections, showing no signs of glacial overriding, thus also seem to support the view that there was no large-scale Upper Zyryansk glaciation in the Byrranga Mountains and south thereof.

2.5.2.3 Sedimentology and Stratigraphy of Cape Sabler

Site descriptions. - The Cape Sabler peninsula (74°33´ N; 100°32´ E) is ca. 2 km wide and 4 km long, reaching southwards into Taymyr Lake (Fig. 2-45). It is separated from its hinterland by a depression more or less in level with the lake, but rises southwards to ca. 39 m a.s.l. The peninsula is bordered by 5-25 m high bluffs, at places actively eroded by the lake and exposing predominantly silty sediments. The same silt is also the deposit exposed on the surface along the main coast north of Cape Sabler. The silt is however considerably thinner there and wedges out at ca. 60 m a.s.l, higher up usually replaced as surface deposit by soliflucted Permian shales. The Cape Sabler sections have previously been investigated by Isayeva (1984), but was then described in a very brief way. However, if Isayeva´s (1984) results - suggesting an in part Upper Zyryansk age of the sediment - can be confirmed, Cape Sabler will be fundamental for understanding the Karginsk-Upper Zyryansk palaeoenvironmental history of the Taymyr Peninsula south of the Byrranga Mountains.

In 1996 the best exposures were found on the eastern side of Cape Sabler. Here the reticulate pattern of ice wedge polygons is actively down-wasting in the bluff zone, forming gullies both perpendicular and parallel to the coastline and thus exposing the interpolygonal sediments. Sometimes also tor-like erosion remnants of frozen sediment are formed. It is thus possible to get a 3D view of the sediment succession, thereby avoiding misinterpretations caused by the frequently occurring, recently resedimented and refrozen gully infills.

At the ca. 25 m high main section worked by us (*Cape Sabler 1*; 74° 32.86´ N; 100° 32.15´ E) it was possible to get access to the sediments in three close-lying profiles, but unfortunately not with overlap between these profiles. The logged succession starts 2 m above the Taymyr Lake level and has two gaps, at 11-12 m and 16.5-17.0 m above the lake. Predominating facies is a massive to vaguely parallel-laminated silt, usually rich in organic detritus (moss stems, wood twigs 0.5-3 mm in diameter, seeds, leaves). The massive facies usually also demonstrate a subhorizontal bedding, showing bed thicknesses varying between 0.5-5 cm. This bedding is marked by horizons with a higher content of organic detritus along which the sediment is easily broken up. Minor facies constituents are very thin beds of massive fine sand (0.3-1 cm), occurring solitary or in intercalated sets, and 4-80 cm thick units of silt-soaked moss peat. Mammoth bones were found beneath the section but not *in situ.*

An additional section was investigated at the northern end of the bluff zone (*Cape Sabler 2*; 74° 33.32´ N; 100° 30.35´ E). The bluff is here only 4.5 m high and there was access to the sediments from 1.5 m above the lake level and upwards (Fig. 2-50). Predominating facies at the base of the section is massive silt with bed thicknesses between 3-13 cm, interbedded with 0.5-2 cm thick beds of organic detritus (predominantly moss). The sediments coarsen upwards into 2-10 cm thick beds of massive fine sand and some graded beds of medium to fine sand. Also these are interbedded with organic detritus, usually in 1-2 cm thick beds.

The Cape Sabler 1 section was sampled at 1 m intervals for ^{14}C-datings and at 10 cm intervals for pollen analysis. Four ^{14}C-datings have hitherto been carried out, yielding 33 800 ± 700 B.P. at the base of the section, 30 200 ± 750 B.P. at +10.5 m, 17 990 ± 170 B.P. at +18 m and 1490 ± 90 B.P. at +24.9 m. The last sample was taken only 0.5 m below the present land surface. This date is at present considered suspiciously young, but this will probably be straightened out by the ongoing dating programme. Approximately 20 more ^{14}C-datings from the Cape Sabler sections are expected in the near future, as well as some dates on mammoth samples. Pollen analysis on the Cape Sabler 1 section is planned and also stable oxygen isotope studies on wood fragments.

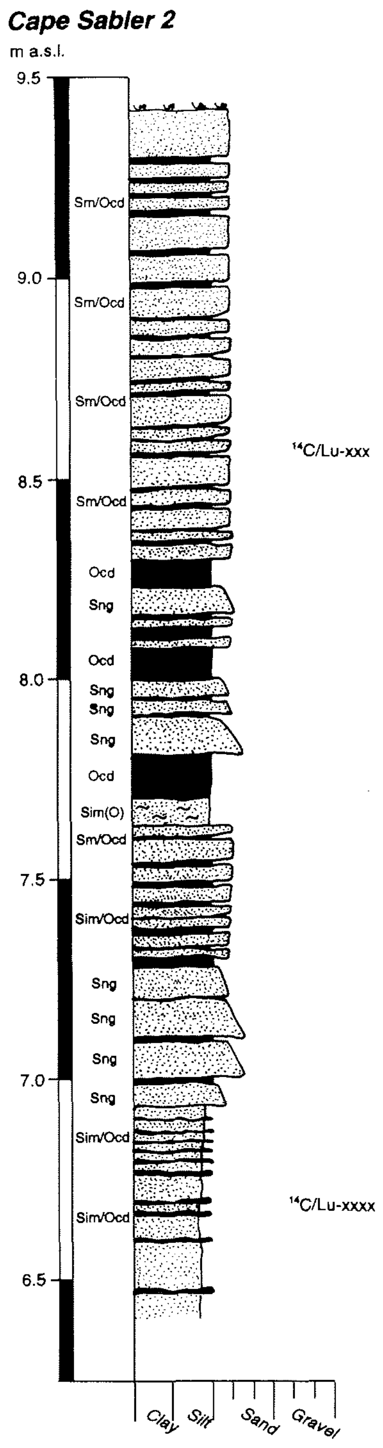


Figure 2-50: Sediment log from Cape Sabler 2. Altitude is measured with reference to the Taymyr Lake level, considered to be 5 m a.s.l. Lithofacies codes: *Sm*, massive sand; *Sng*, normally graded sand; *Sim*, massive silt; *Sim(O)*, massive silt with high content of organic debris; *Ocd*, coarse detritus organic matter. Note that the organic detritus, marked with black, is not related to the grain-size scale at the base of the log. Positions of samples taken for ^{14}C-dating are indicated in the log.

Preliminary interpretations and palaeoenvironmental implications. - The depositional environment of the Cape Sabler sediments is not yet quite clear. At the moment we consider two possibilities: (1) the sediments are lacustrine, deposited in a paleo-Taymyr Lake with a maximum lake level around 60 m a.s.l. The very high content of coarse organic debris, which we believe was flooded into the basin in the snow-melt season, indicate a shallow depositional environment. Shallow water deposition is also indicated by the frequently occurring massive and graded sand beds. This in turn suggests that the sediments were deposited during a transgression towards a maximum lake level. An alternative interpretation (2) is that the sediments were deposited in a subaerial environment during flood stages (snow-melt peaks), in a lateral position to a main fluvial channel. Very similar sediments - silts with a high organic content and occasional sand beds - were observed in lateral positions to active, coarse-grained braidplains during our reconnaissance trip in the Byrranga Mountains. This latter alternative also postulates a high and transgressing lake level as, if the bas-level did not rise there could hardly have been a vertical accretion of ca. 35 m of sediments in a subaerial environment. The wide distribution and thickness of the Cape Sabler sediments favours the first interpretation, the abundant occurrence of mammoth remnants in the sediments might favour the second alternative. However, both alternatives suggest a damming of the Taymyr Lake basin to 50-60 m a.s.l. and one possible explanation for this would be a blocking of the trans-Byrranga part of the Taymyr River by a southward expanding Kara Sea ice sheet.

Isayeva (1984) and Arkhipov *et al.* (1986) favoured a glacial cover over the Byrranga Mountains during the Upper Zyryansk, with a maximum extension marked by the Dzhangodo - Syntabul - North Kokora marginal formation some 200 km south of the Cape Sabler locality. However, the ^{14}C dates from the Cape Sabler sequence, although few at the moment, seem to go well back into the Kargisk interstadial and are continuous throughout the time-frame of what is considered to be an Upper Zyryansk glacial. The sediments are not covered by glacial deposits and show no glaciotectonic disturbances. The sequence and the age span it represents thus contradict the idea of a glacial cover of the Taymyr Lake basin during this period, and thus any extension of an Upper Zyryansk ice sheet reaching south of the Byrranga Mountains. It should however be mentioned that the latter scenario was also held open by Isayeva (1984), as an alternative to the more traditional view of a widespread Upper Zyryansk glaciation of most of the Taymyr Peninsula.

Continued work on the Cape Sabler sediments should further substantiate these preliminary results, and hopefully again demonstrate that this is a key locality for the understanding of the glacial and environmental history of the Taymyr Peninsula.

2.5.3 Permafrost Landscapes and Geocryology of Cape Sabler

(A. Dereviagin, C. Siegert, E. Troshin, E. Simonov)

2.5.3.1 Methods

Geocryological investigations in permafrost regions give an additional paleogeographical information and greatly completes sedimentological and stratigraphical studies of Late Pleistocene sequences. The basic method for cryolithological investigations of permafrost sequences is the frozen ground facial analysis (Katasonov 1978). This method is based on the relationship between the cryogenic construction of sediments and the paleogeographical conditions at the time of sediment freezing. In the Cape Sabler region (Fig. 2-51) the geological and cryogenic structure was studied in five sections and one bore hole. Granulometrical, mineralogical, geochemical analyses, as well as pollen and diatom analyses, are planned. Our investigations at Cape Sabler also suggests intensive application the radiocarbon (^{14}C) dating method.

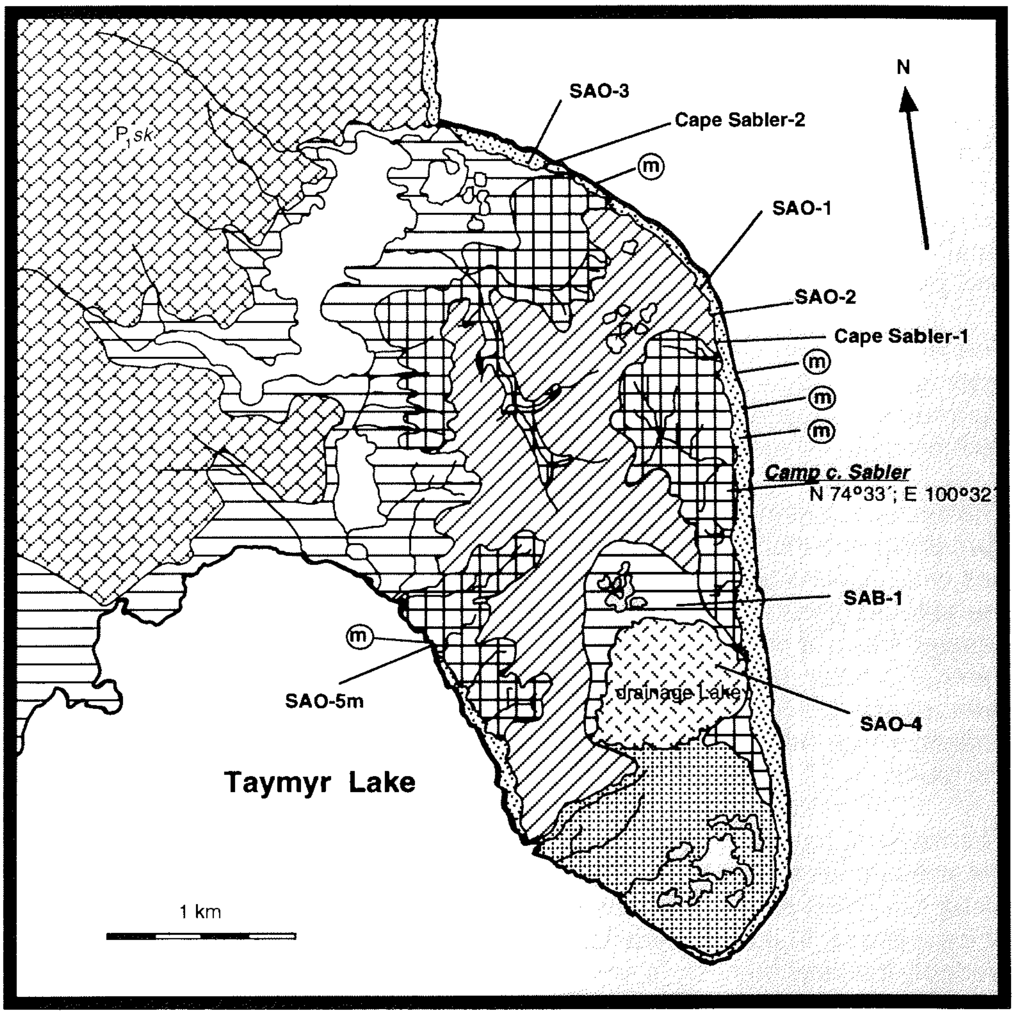
The main attention was given on the investigation of cryolithological features of the sequences. All types of ground ice (ice wedges, ice sheets, texture ice) were sampled for isotopic analyses, including $\delta^{18}O$ and $\delta^{2}H$ values and evaluation of tritium (^{3}H) content. Oxygen ($\delta^{18}O$) and hydrogen ($\delta^{2}H$) stable isotope variations in natural systems have been widely used in the interpretation of past climatic conditions. Although there has been much research on stable isotope variations of glacier ice, far less is known about permafrost ground ice.

Our preliminary results on isotopic composition of ground ice obtained in 1994-95 in the Labaz Lake region (Fig. 1-1) have shown good agreement of the isotope data with paleoclimatic reconstructions in the region (Siegert et al. 1996). It is necessary that a more thorough study of the method is performed. Therefore, particular attention was given to careful sampling of ice. We used special sampler allowing us to take punctate samples of ice. Sampling of thick ice wedges and ice bodies was carried out across a net with sample intervals of about 20-30 cm. More than 120 samples of different types of ice (sheet ice, ice wedges, and texture ice), precipitation, and surface water were collected during the field season 1996.

The study of modern ice formation processes was continued in 1996 with application of tritium analysis. Tritium is an indicator of moisture transportation processes, being a radioactivity component of water molecules, and examines the content of modern water in permafrost (younger then 1953 - the beginning of entrance the "bomb" tritium in precipitation). Therefore, tritium analyses are applicable for studying modern cryogenic processes and water transfer in systems including a seasonal thawing layer and permafrost.

2.5.3.2 Investigation Area

Cape Sabler is located at the north-western shore of Taymyr Lake in a region with continuous permafrost. The thickness of permafrost was estimated to about 300 - 500 m (Ershov, 1989). A chain of shallow-water lakes separates Cape Sabler from the Byrranga submountain in the north-western part of the area. The gentle slope of the main range of Byrranga Mountains lies directly behind the lakes (Fig. 2-51). Here, the Permian terrigenous deposits striped by erosion are presented by siltstones, sandstones, claystones, and limestones of Sokolinskaya suite (P_1 *sk*).



LEGEND:

- predominance of thin-lalyered solifluction sheets on Permian bedrocks (P_1 *sk*), rock streams;
- poligons, bogs with low centre poligons, thermal erosion;
- hummocky terrain with rare thermokarst lakes;
- predominance of cemetery mound (baydzerakh) and solifluction features;
- nivation, solifluction lobes, solifluction terraces;
- cemetery mound, thermal erosion;
- beach;

SAO-1 - section of Russian participants;

Cape Sabler-1 - section of Sweden participants;

(m) - foundings of mammoth bones;

Figure 2-51: Map of permafrost landscapes and study sites in the Cape Sabler region, western Taymyr Lake (for location see Fig. 1-2).

A few stages of attached terraces with not clear boundaries were observed at Cape Sabler. They have altitudes of 5-6, 8-10, 14-18, and 25-30 meters above the Taymyr Lake level (which is 6 m above sea level). Seasonal changes of lake level are 4-6 m with a minimum in the beginning of August. The terraces constitute to predominantly silty lacustrine sediments with interbeds of peat and plant remains (detritus). The vegetation of the area belongs to the Arctic Tundra subzone. The dominant components of plant communities are sedges (*Cyperaceae*), mosses, and lichens with some species of *Salix* in local depressions. There are wide spreadings of hummocky tundra, tussocks, and polygons.

The landscape of Cape Sabler is characterized by a wide spreading of permafrost landscapes features: frost cracks, polygonal ground, ice wedges, thermokarst mounds (baidjerakh), thermokarst depressions, thermal erosion, spot medallions, solifluction features, nivation (Fig. 2-51).

The terrace surfaces are plane, convexo-plane, and usually dry with a rare spreading of small thermokarst lakes (depth about 1 m). Polygonal ground has wide expansion on the surface. As a rule, polygons are pentahedral, with the side lenghths of about 7-15 m. In the polygonal surface two parallel processes were observed: frost cracking with ice wedge formating and active thermal erosion processes along the thick ice wedges (SAO-1). The modern thermokarst processes are due to thawing of numerous ice wedges and ice bodies, which have a wide expansion in the Cape Sabler area particularly at the bluffs.

Thermokarst moundes (or baidgerakh) are the most characteristic features of the mesorelief at the bluffs. There are three stages of cemetery moundes along the coast line of the cape as a result of thawing of several generations of ice wedges. In the north-eastern and south-eastern parts of the area, the ice wedges thawing process is very active at present. Therefore, the slopes of lake-shore terraces here constitute the alternation of steep ice-wedge walls stripping different ice complexes, and large solifluction lobes. In some places in the terraces there are small valleys with streamlets in the bottom and snow patches remaining throughout the summer in the slopes. Here, the processes of nivation are observed.

A drainage lake (alas) is located in the southern part of the peninsula (Fig. 2-51). According to aerial photograph interpretation this lake was existing until 1950. At present, its surface is covered with meadow vegetation. There are systems of polygons of thawing ice wedge having thicknesses of about 4-5 m (SAO-4) in the bottom of the drainage lake. To the south of the lake depression, the site of bog with low centre polygones is located. Here, very active processes of modern thermal erosion were observed.

Solifluction features (solifluction terraces, solifluction lobes, and also solifluction sheets) have wide spreading in the slopes of the area. In Permian bedrocks, there are numerous dells, sorted stripes, and rock streams in the slopes.

2.5.3.3 Cryolithology Features of the Sequences

The Late Pleistocene sediments in the Cape Sabler area contain complex systems of thick ice wedges, different types of texture ice, and massive ice bodies (sheet beds) with unknown origin. Ice wedges are especially common in the sediments of terraces 25-30 m, 12-18 m, and 8-10 m above Taymyr Lake level (Fig. 2-52).

The profile of the 28 meter terrace (sections SAO-1, SAO-2) is presented by continuous series of massive and parallel-laminated silt (with organic detritus and plant remains), and interbeds of silt-soaked moss peat. The profile looks like "puff pie". A series of ^{14}C data (from Karginsk to Holocene) was obtained for the terrace sediments by N.V. Kind et al. (1981):

GIN-1521	(peat)	30,300	±	300	^{14}C yr BP
GIN-1523	(detritus)	30,400	±	600	^{14}C yr BP
GIN-1524	(detritus)	24,200	±	800	^{14}C yr BP
GIN-1525	(detritus)	21,400	±	1100	^{14}C yr BP
GIN-1526	(detritus)	18,400	±	1000	^{14}C yr BP
GIN-1529	(detritus)	13,600	±	400	^{14}C yr BP
GIN-1528	(detritus)	12,100	±	100	^{14}C yr BP
GIN-1527	(detritus)	11,600	±	100	^{14}C yr BP
GIN-1288	(detritus)	2580	±	160	^{14}C yr BP

Unfortunately, we have no accurate altitude data for these absolute age determinations. Our own ^{14}C data, which will be determined during this year, shall complement these existing data.

The sediments of the 25-30 m lake terrace include several stages of thick ice wedges (Fig. 2-53). The first stage (from the surface) of the polygonal ice wedge system is located within the range from 0.6-0.7 m to 5 m (SAO-1, IW-2, IW-6, IW-7). These are the typical syngenetic ice wedges with representative border zones and heads in their upper parts. The width of ice wedges is about 5-7 m. Ice has the characteristic subvertically layered structure and contains mineral particles and air bubbles. The second stage of ice wedges is situated in a depth from 6 m to 10-17 m (Figs. 2-53 and 2-54). These are also syngenetic ice wedges with a width of about 2-5 m and eroded upper boundaries. The third stage of ice wedges has been exposed on the depth 20-21 m (SAO-1, IW-5; SAO-2, IW-1). These are also syngenetic ice wedges with eroded upper boundaries, having widths between 0.5-0.8 m and 3-4 m. The upper parts of all ice wedge horizons have contacts with peat interbeds.

A thick, massive ice bodies of unknown origin was found in the upper part of the terrace at 25-30 m (Fig. 2-55). It has an approximate thickness of 4-5 m and width of 10-15 m. The ice shows horizontal layering, with thicknesses of individual ice layers of about 0.4-0.6 m. An interstratification of clean, transparent ice and turbid, "dirty" ice with mineral particles and air bubbles was observed. We suppose that this ice body represents a, buried perennial firn field.

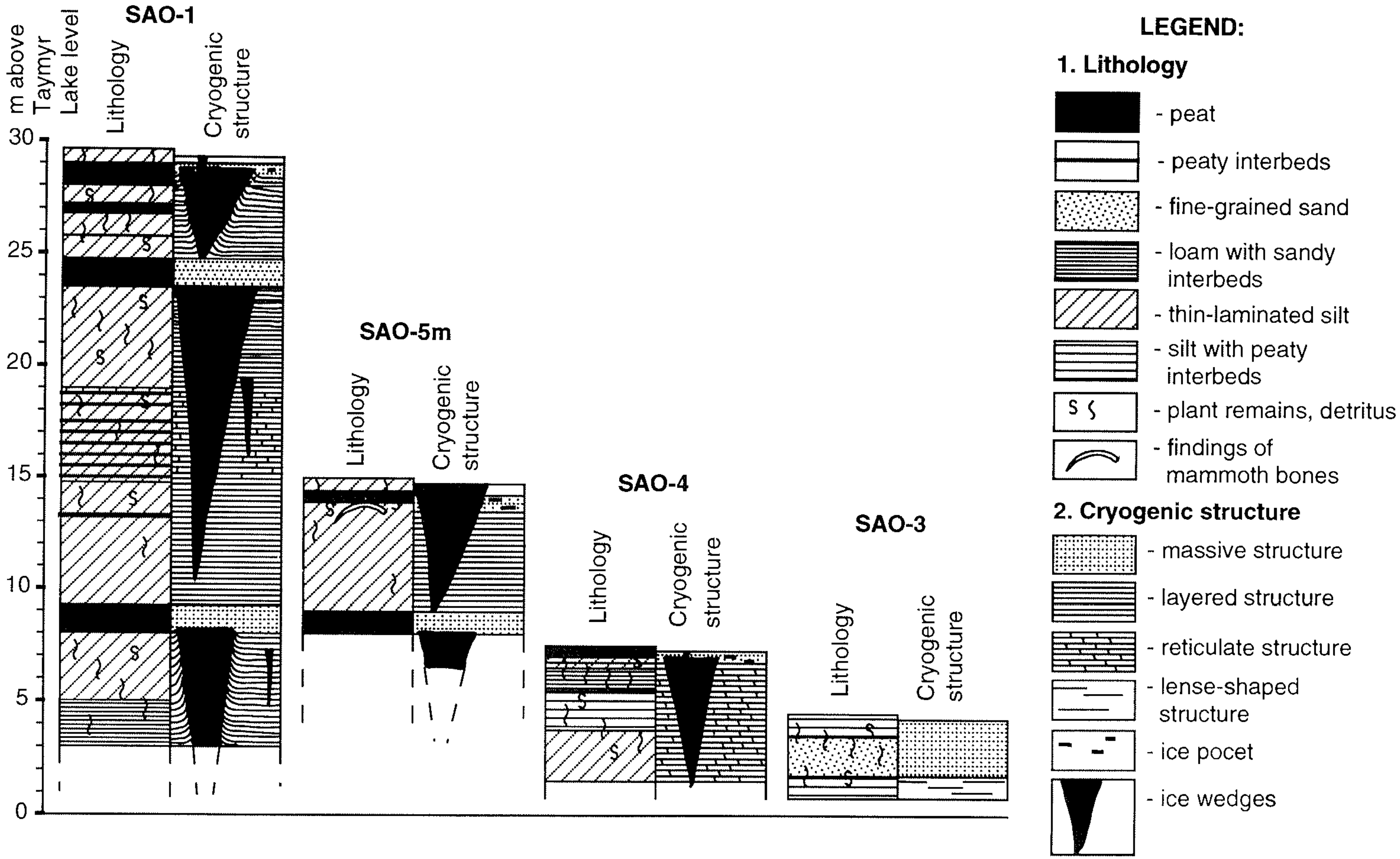


Figure 2-52: Cryolithological profiles of Late Pleistocene sediments in the Cape Sabler region (for locations see Fig. 2-51).

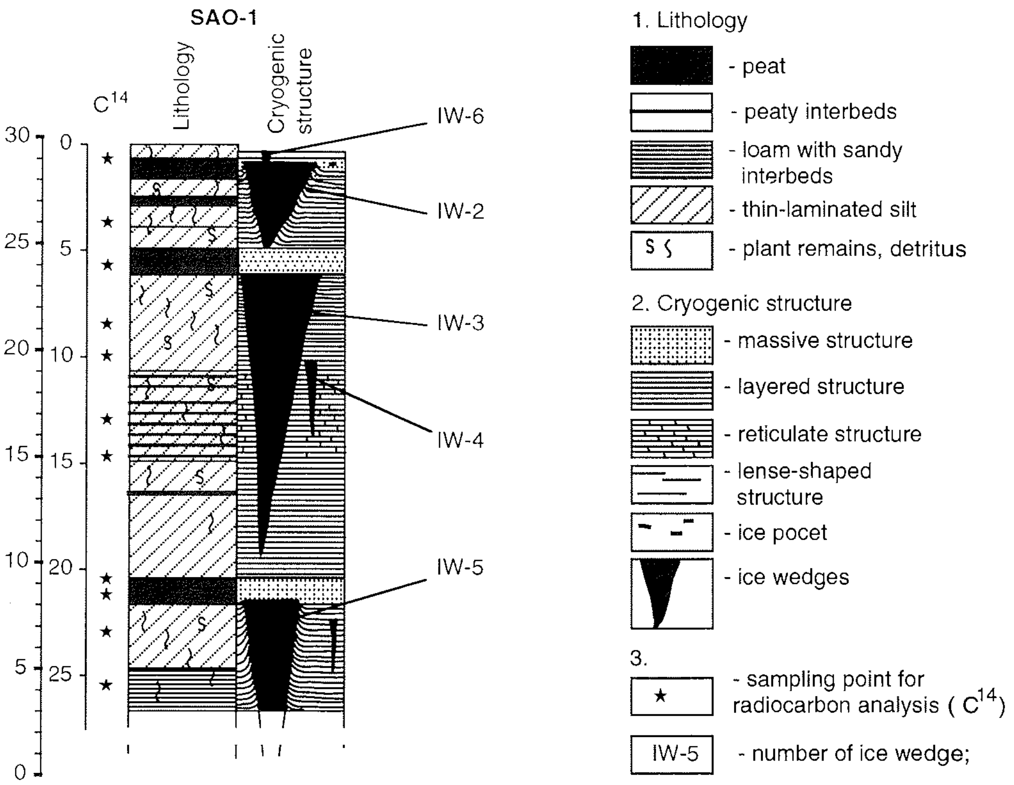


Figure 2-53: Cryogenic construction of the section SAO-1 (for location see Fig. 2-51).

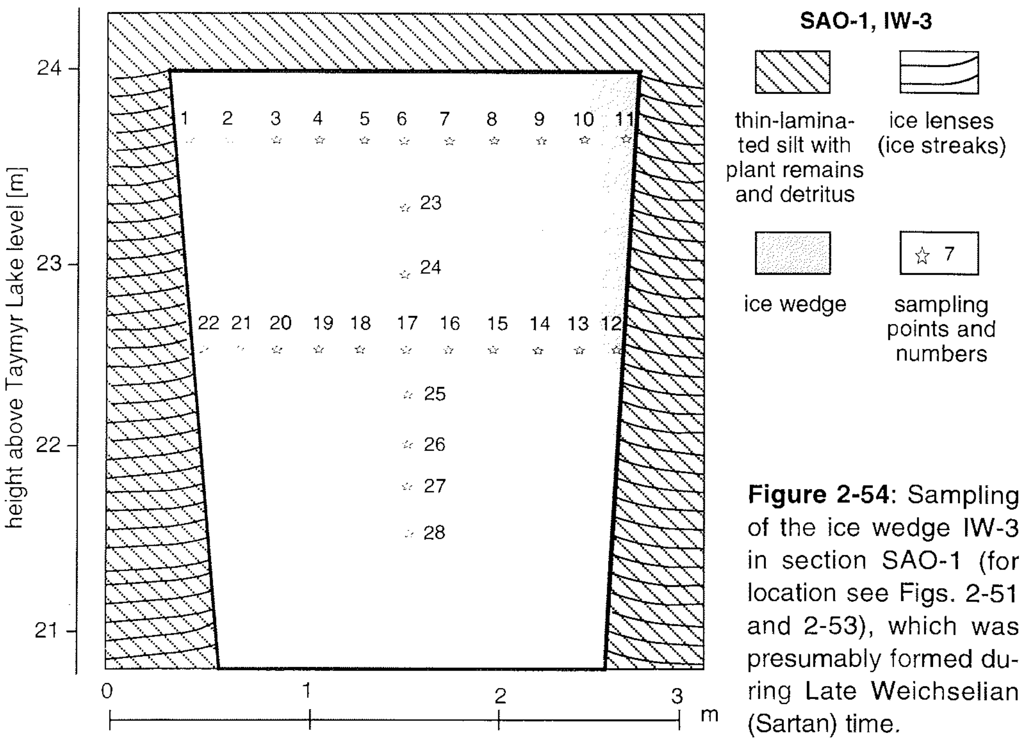


Figure 2-54: Sampling of the ice wedge IW-3 in section SAO-1 (for location see Figs. 2-51 and 2-53), which was presumably formed during Late Weichselian (Sartan) time.

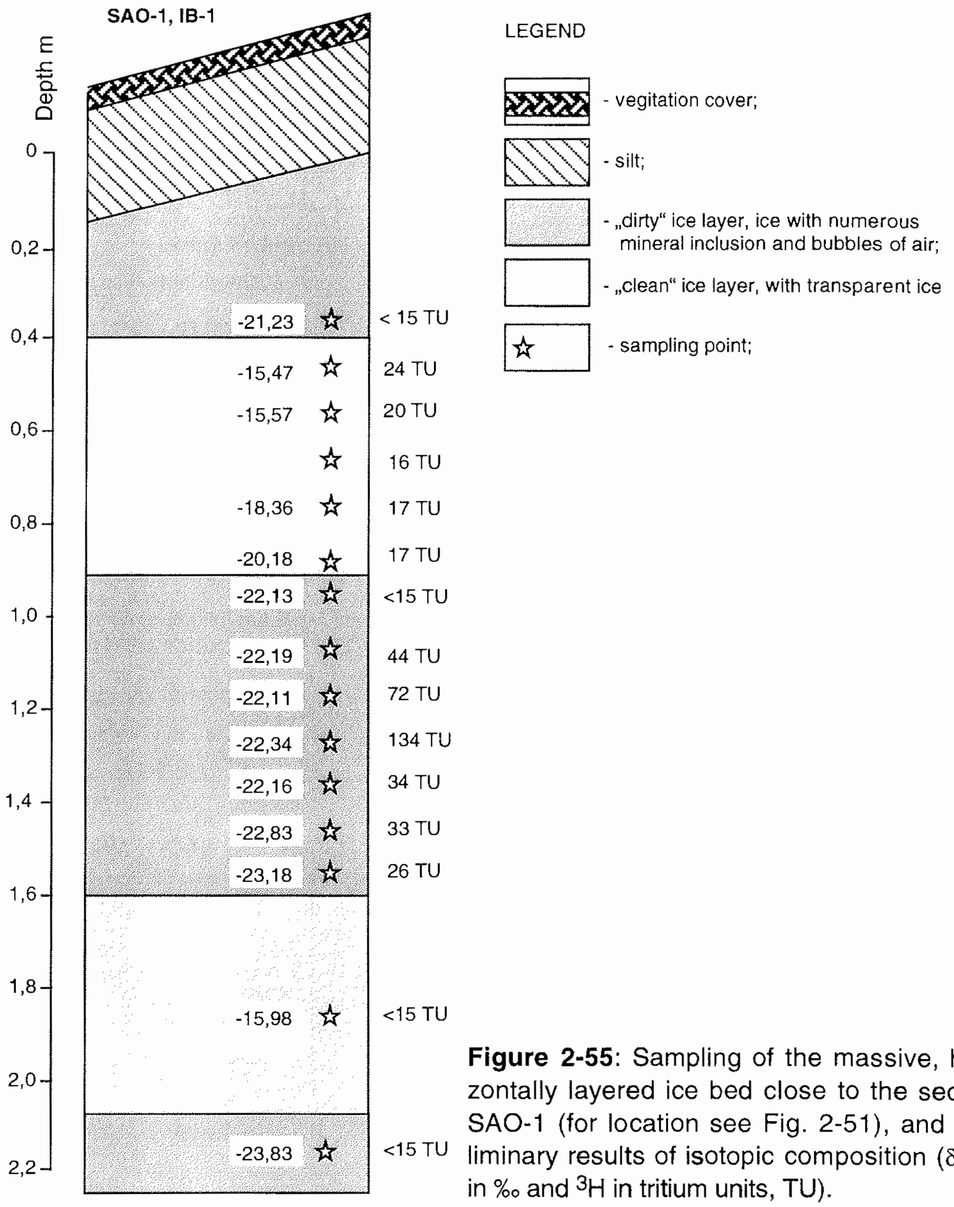


Figure 2-55: Sampling of the massive, horizontally layered ice bed close to the section SAO-1 (for location see Fig. 2-51), and preliminary results of isotopic composition ($\delta^{18}O$ in ‰ and ^3H in tritium units, TU).

The sediments of the 14-18 m terrace also contain two stages of thick syngenetic ice wedge systems. The widths of ice wedges extend 5-7 m. Observed thicknesses of ice wedges are more than 4-6 m. Numerous fossils of mammoth (bones) were found in the section of this terrace at the surface of ice wedges. The most interesting finding were *in situ* mammoth fossils at a depth of about 2.0-2.5 m depth in grey silt with plant remains (SAO-5m). Samples for ^{14}C analysis were collected. The sediments of the 8-10 m terrace also contain a system of polygonal ice wedges, which have thicknesses of about 5-6 m. Intensive thawing of all ice wedges was observed in the area during summer 1996.

2.5.3.4 Preliminary Results

The following, preliminary results were obtained during the field work 1996 in the Cape Sabler region and from first analytical work on the comprehensive sample sets (see Tables 6.5 - 6.7 in Annex):

- Late Pleistocene sediments at Cape Sabler contain different types of ground ice: a complex system of thick syngenetic ice wedges, thick ice bodies with unknown age and genesis, and texture ice.
- Each stage of sedimentation is characterized by both lithological and cryo-lithological structural features.
- Three stages of syngenetic ice wedge formation were observed in the profile of the 25 m terrace. The upper parts of all ice wedge horizons have a contact with peat interbeds.
- Numerous fossils of mammoth (bones) were found in the section SAO-5m as well as at the Taymyr Lake shore.
- The tritium contents in ground ice samples vary within a range from less than 15 TU to 134 TU in dependence on the age, genesis and recent cryo-lithological processes. An anomaly high tritium concentration (415 TU) was found in a snow patch remaining throughout the summer 1996. This phenomenon should be considered in the interpretation of tritium analysis data.

2.6 Geomorphological Studies

2.6.1 Route from Schel´ Lake to Bolshaya Bootankaga River

(G.B. Fedorov, A.Yu. Ivanov)

During the period August 8 to 15, 1996, we sailed in a rubber boat from the Schel´ Lake to the mouth of the Bolshaya Bootankaga River. The main goal of this trip was to collect data on paleogeography, geomorphological structure, and Quaternary deposits of the region. The total length of the route was about 50 km.

The main aims of the studies of geomorphological structure and Quaternary deposits along the route were

- to measure the depths of the Schel´ Lake,
- to reveal and investigate lake terraces,
- to collect cores of bottom sediments from the lake for different kinds of analyse, and
- to investigate the structure of terraces of the Levli and Bolshaya Bootankaga Rivers.

The Schel´ Lake is about 4 km in length and up to 900 m in width (Fig. 2-56) lake water level 116 m above sea level. It is oriented from north-north-west to south-south-east and drained by the branch falling to the Levli River. The lake is situated in a narrow trough of tectonic origin. The amplitude of the above water relief reaches 500 m at the maximum width of 2.5 km. The slopes of the trough are slightly dissected errosionally with the mean slope angle of about 25°. The streams entering the lake have steeply entrenched V-shaped valleys. Their debris cones are of oblique bedding and are controlled by the slopes. The material composing the debris cones and confined to the shoreline consists of large poorly rounded fragments.

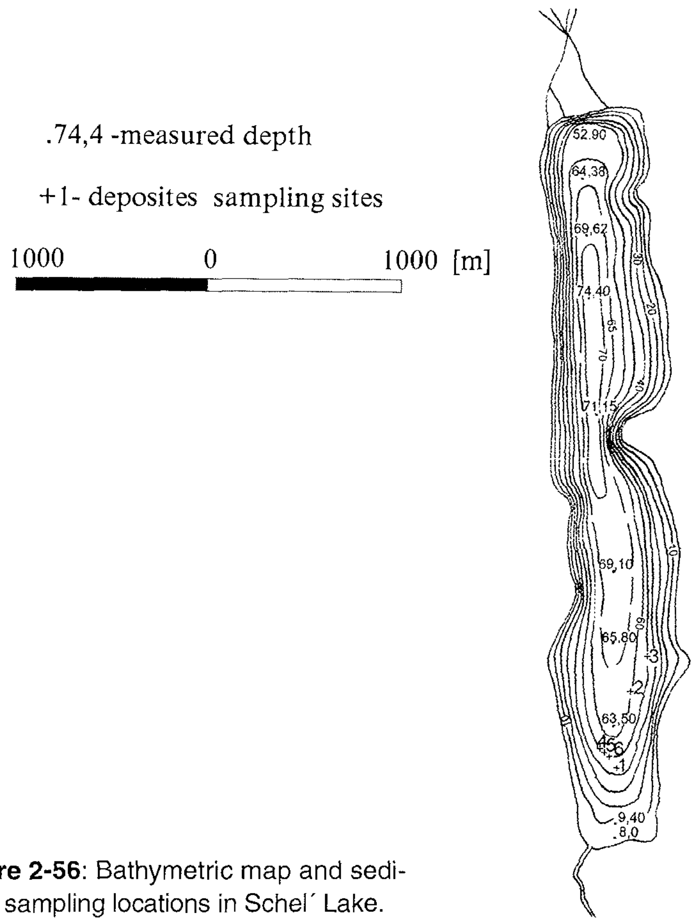


Figure 2-56: Bathymetric map and sediment sampling locations in Schel´ Lake.

The largest water stream flowing to the Schel´ lake is the stream falling from the north-north-western tip. In fact, these are two streams whose valleys are oriented north-north-westward and north-eastward merging only in the mouth zone. The mouth zone of the inflow under consideration is within the lake trough itself extending over 2 km. This is a slightly inclined lacustrine-alluvial surface. In this zone of the trough there is a pronounced accumulative pebble terrace about 11 m above the lake water line confined to the trough slopes. In 2 km from the place where the stream enters the lake on the right slope of the valley two samples of the deposits of this terrace were taken for radiocarbon analysis. The accumulative-pebble body of the height relative to the lake water line is also observed at the south-south-eastern tip of the lake. By height and the composing material, it correlates well with the terraces occurring in this zone in the Levli River valley. Small area sites of same height are also found at the north-eastern and south-western slopes of the lake trough.

The depth measurements in the Schel' lake were carried out from the boat by means of a lead. In total, 15 measurements were performed. The maximum observed depth was 74.4 m. Based on these measurements, a bathymetric scheme of the lake was made (Fig. 2-56). Sampling of bottom sediment cores in the Schel´ lake was performed by a GOIN corer. In total, 6 cores from the sampling site were collected.

The valley of the Levli Lake is located along the tectonic fracture. In the zone where the branch from the Schel´ Lake falls to the river, the valley narrows up to 1.5 km although upstream its width reaches 2.5 km. A pronounced accumulative terace about 11 m high is confined to this zone of the valley. As is seen from the cartographic material, it is absent both downstrean and upstream.

The Levli River is the largest tributary of the Bolshaya Bootankagi River. In the place of their confluence they have a common terrace about 7 m high differing from the 11 m high terrace not only in height but also in the composition of deposits. In this case, peat-bogs, sands and pebble-beds with a large organic content are stripped in the outcrops. In this zone in the valleys of both rivers there are observed the sites of the accumulative pebble terrace 100-120 m high whose outcrops of deposits were nowhere found. The character of the channel process in the lower reaches of the Levli River changes from forced meandering to the flood-plain branching which is typical of the middle and downstream current of the Bolshaya Bootankagi River.

The valley of the Bolshaya Bootankagi River in this zone reaches 5 km in width and in the lower reaches 7.5 km. The cross-profile has a swally-like form. Unlike the upstream zones, where the studies were conducted in the previous years, the structure of the valley is a little different. The terraces are not presented by narrow strips, but occupy considerable areas. The terrace 5 m high in whose outcrops mainly peat-bogs and sands are outstripped is well-pronounced. No hanging valleys of the lateral tributaries with thick debris cones as upstream, are observed. The rivers have several layers of the flood-plain. The surface of the high flood-plain is well-tufted.

2.6.2 Bank Dynamics in the Krasnaya River Estuary

(M.A. Anisimov, O.G. Romaschenko, M.V. Ryazanova)

During the field season 1996 a theodolite survey was carried out in the estuary area of the Krasnaya River to the north of Levinson-Lessing Lake (Fig. 2-57). The work concentrated on the most washed-out places of the banks belonging to the first terrace above the flood-plain.

The steep banks with unturfy slopes in the lower reaches of the river and about a kilometer above the estuary on the right at the place of ice wedge outcrops underwent the most intensive erosion. Far above the estuary the river has a wide, pebbly flood-plain, where the banks become more gently sloping. Flood-plain slopes are covered with turf, which indicates the absence of any considerable erosion of the first super flood-plain terrace of the river.

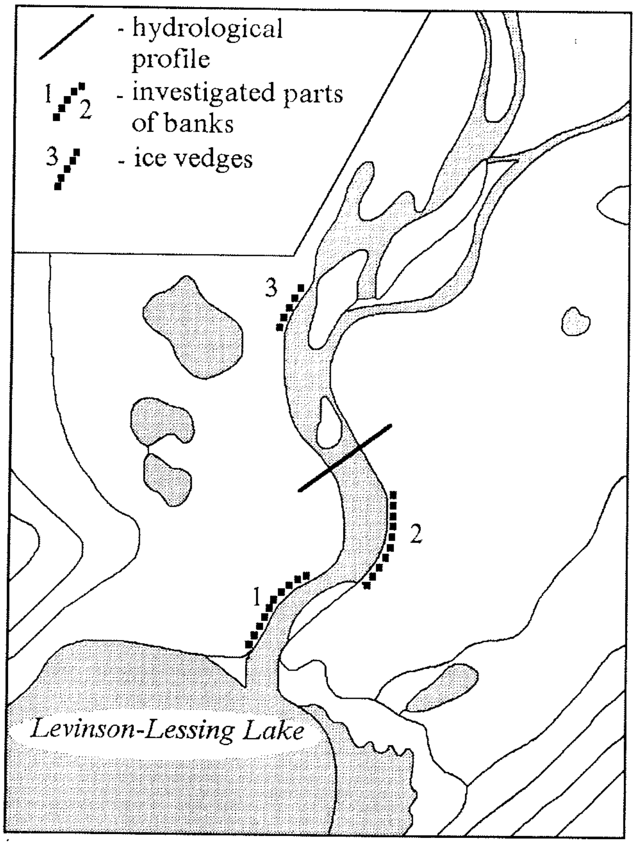


Figure 2-57: Map of the lower Krasnaya River showing the areas of field studies for bank dynamics and the location of the hydrological profile.

At the estuary areas being considered receeding of the edge of the first super flood-plain terrace takes place as a result of erosion of the bank and tearing off big pieces of earth by cracks and ice veins. The blocks brought down are subjected to erosion in the riverbed. The material in the form of suspended and carried along alluviums is accumulated in the delta and carried out into the lake. Separation of blocks by the cracks is accompanied by their seating apart and landsliding. Due to this fact, the survey of the edge was carried out along the marginal parts of steady blocks which were not seated apart or slided.

The first survey was carried out at July 1 to 2, 1996, before the beginning of flood at the river and firn thawing in the river-bed. The repeated measurements were done at Aug. 9, 1996, after the fall of the level and its relative stabilization at the end of the field period. The whole lenght of the coastline measured amounted to about 300 metres. Comparing the data obtained, it can be concluded that during July-August the magnitude of each retreat of the shore, without changing the morphology of the river-bed cross profile, made 1.5 m in average.

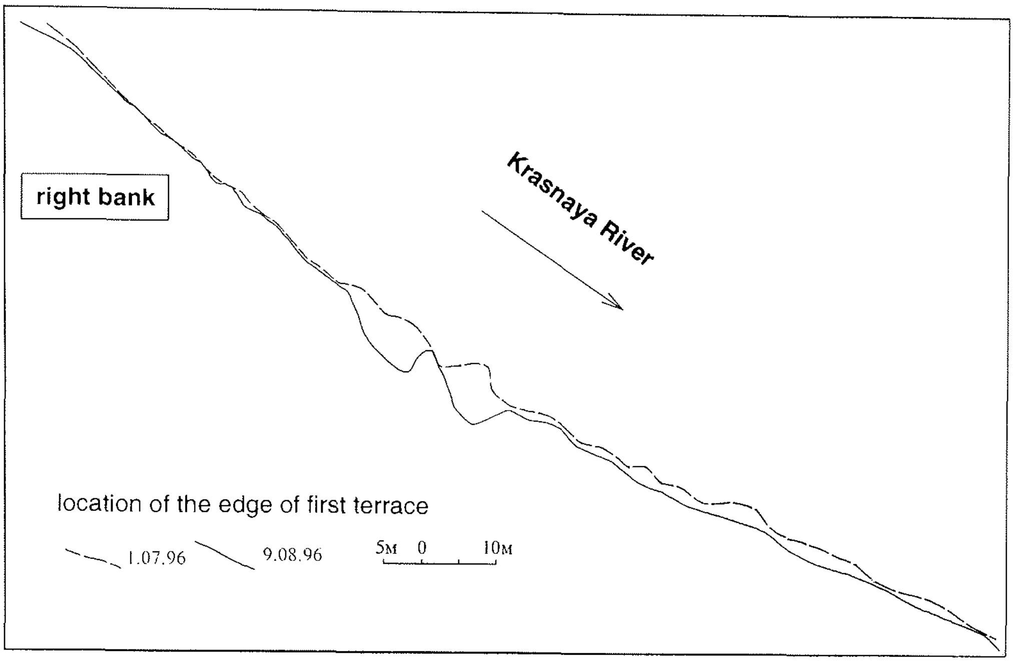


Figure 2-58: Thermoerosion between July 1 and Aug. 9, 1996, at the eastern bank of the lower Krasnaya River (for location see Fig. 2-57).

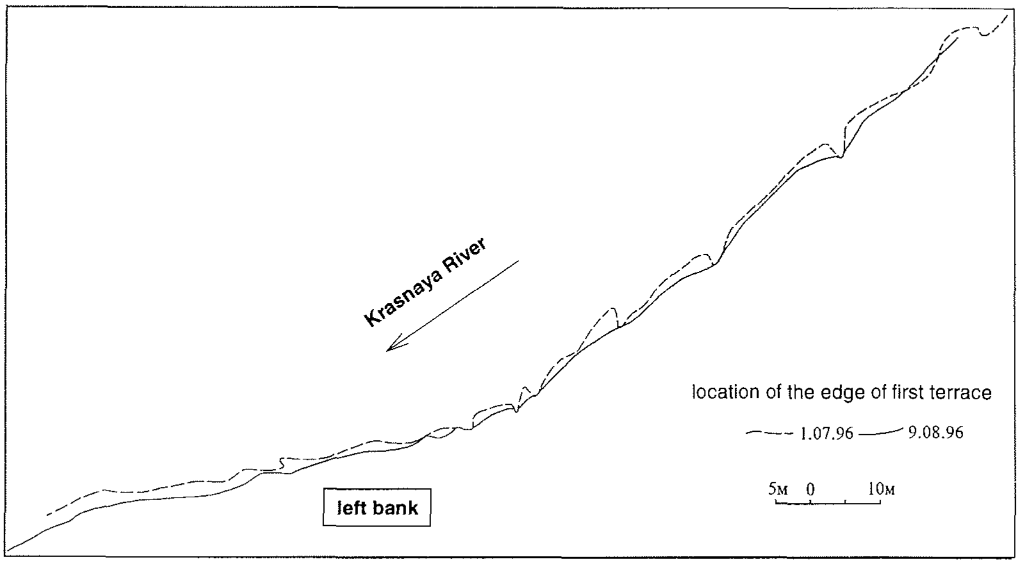


Figure 2-59: Thermoerosion between July 1 and Aug. 9, 1996, at the western bank of the lower Krasnaya River (for location see Fig. 2-57).

Single parts of the banks receeded by insignificant distance, due to their partial blockade by seated apart blocks, whereas others receeded by maximal distances up to 6.5 m (on the right bank). In some cases, separating of congealed earths without their considerable seating apart took place, as a result of which, in two cases, the coastline shifted towards the river.

A rough estimation of the volume of eroded material and destroyed banks of Krasnaya River below the range of the hydrological observation showed that it amounted to 2,500 - 3,000 m^3. For this estimation, the bank height from the edge of the first river terrace to the river level, the specific weight, porosity, and type of earth were taken into account.

The data obtained allow to conclude that the mass of material comes down and is transported by the river through the range of the hydrological observation is commensurable with the amount of material coming into the river when erosion of the banks in the lower reaches. Thus the suspended drift measured at the range differ from the real ones coming into the lake and the error of the measurement is significant.

2.6.3 Studies of Terrace Levels at Levinson-Lessing Lake

(M.A. Anisimov, O.G. Romaschenko, M.V. Ryazanova)

During the field season in 1996, a geomorphological visual-instrumental survey was carried out at the watershed of Levinson-Lessing Lake. The task of the field observations was the determination of terrace levels heights. Terraces and terrace-like forms of relief were the main objects of investigation (Fig. 2-60). The work was performed with barometer-aneroid, level (H-3), and theodolite (T-30).

Geomorphological routes covered the whole territory adjacent to Levinson-Lessing Lake. In addition, several routes to the north of the lake, to the regions of Mramornaya and Zamknutaya River mouths, and to the south, to the Ledyanaya River valley, were fulfilled. During route investigations, the sites of observation were described in detail. Altogether 109 descriptions and 757 instrumental measurements of absolute and relative heights of the terrace-like forms of relief were carried out. At some terraces their structure was investigated by dug holes.

As one of the highest among the levels considered we chose a marine terrace of 100 metres, well-saved, spread not only in the region of the Levinson-Lessing Lake watershed, but also far beyond its boundaires - in the valleys of the rivers Ledyanaya, Karovaya, Uglenosnaya, Verkhniaya, Nizhniaya Taymyra, and others. This terrace has well-defined horizontal areas, is composed or recovered by well-rounded material, and sometimes occurs as an abrasion terrace, cut in the original rocks of structural-denudation ridges, perpendicularly coming to the lake level. Those terrace-like forms of relief which are located higher have disputable genesis, indefinite range of heights and are situated at far distances from each other.

As a result of the research carried out, eleven terraces were defined (Fig. 2-60, Table 2-10). They were divided into two groups, differing in height, type of underlying material (shape, size, extent of rounding), and height position between Levinson-Lessing Lake and Ledyanaya River.

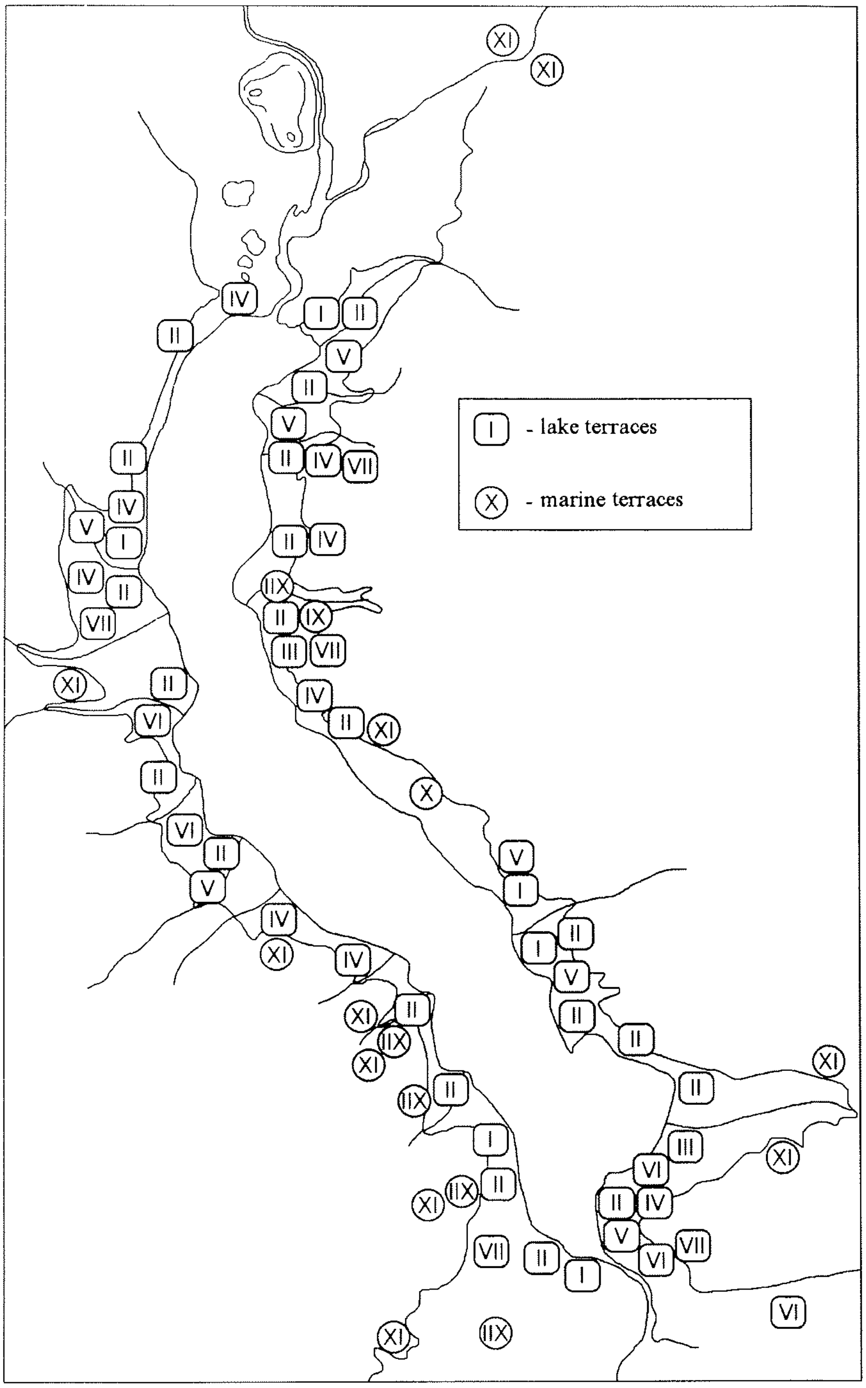


Figure 2-60: Map of Levinson-Lessing Lake terraces.

The marine complex includes four terraces with altitudes of 99-101 m, 89-90 m, 84-86 m, and 75-77 m (we cannot exclude that some of these terraces were formed by a much larger fresh-water reservoir than Levinson-Lessing lake). The sea terraces are characterized by round-shaped pebbles with sizes of 1.5 to 5.0 cm and a high extent of rounding. The ratio between rounded material and the material from rock-waste and land-waste fractions often makes 7/3, sometimes single boulders with a diameter of up to 30 cm can be found. The lowest marine terrace corresponds to the height of the water divide between Levinson-Lessing Lake and Ledyanaya River (27-29 m above lake level). At the stage of this terrace forming, the lake was still a narrow bay of a larger reservoir. The consequent fall of the level led to the formation of a separated reservoir, the Levinson-Lessing Lake. The formed lake was connected with the reservoir left behind the water divide through a narrow stream (Protochnaya River) laid in an ancient fault in a structural-denudation ridge (otherwise erosion of a part of the water-divide saddle would have happened). Since then, this breaking served as the only channel through which the lake drain takes place.

Table 2-10: Terrace types and levels in the surroundings of Levinson-Lessing Lake.

complex	type	altitude above lake level [m]	altitude above sea level [m]
marine complex	XI	51 - 53	99 - 101
	X	41 - 42	89 - 90
	IX	36 - 38	84 - 86
	IIX	27 -29	75 - 77
lake complex	VII	22	70
	VI	13	61
	V	10	58
	IV	3 -4	51 - 52
	III	2	50
	II	1	49
	I	0 - 1	48 - 49

The second group includes seven terraces which we named "lake terraces" (we mean Levinson-Lessing Lake itself). The terraces of the lake complex are spread rather evenly along the lake perimeter. An exception are two levels, of 2 and 13 meters above the lake surface, which tend to the south and central ("bending") parts of the coast. Such tendency can be connected with the dominating north direction of winds and, hence, with increased activity of ice exaration on the coast when opening the lake after break-up of ice. The 13 m lake terrace appears also beyond the lake watershed - in the Ledyanaya River valley. It gives evidence that during its formation a reservoir had existed, which was situated in the region of the confluence of the present Protochnaya and Ledyanaya Rivers with a level close to that of Levinson-Lessing Lake. The existance of this terrace in the Ledyanaya River valley is another evidence of the existance of fault along the present valley of Protochnaya River before the lake separation. The highest terrace from the lake complex - of 22 m - is presented by insignificant in size but well-shaped grounds quite rarely - in the whole five fragments evenly spread around the lake perimeter were found.

After the isolation its own hydrodynamic regime was established in the lake, which effected the type of the material re-covering the surface of its terraces.

"Lake" pebble differs very much from "Marine" pebble. It varies in size, but small-sized (0.5-2.0) pebbles prevail; it is similar in its morphology with the material composing the present pebble beach barrier, i.e. complanate, sometimes sub-angular.

The terraces of the lake complex often occur at alluvial fans of brooks flowing down into the lake from framing it slopes. Depending on steepness of the slopes, all the alluvial fans were divided into three groups: 1 - 2, 3 - 5, and 6-10 degrees. It is interesting to be pointed out that at the cones from the first two groups, i.e. with the slope angles below 5 degrees, in different places practically all the range of terrace levels of the lake complex can be found; especially widely spread are the terraces with the heights 1 m and 10 m above the lake level. There are no high lake terraces on the steeper alluvial fans.

2.7 Archaeological Survey in the Upper Taymyr River Area
(V.V. Pitul'ko)

A very interesting location was discovered in 1994 by geologists from Khatanga Geological Survey Service in the area of Upper Taymyr River near the Oleny Brook (a small right tributary of the river) mouth, at 74°08′ N, 79°06′ E. Although the cultural layer exposed in the right river bank was supposed to be dated to 5,000 - 9,000 yr BP, it is much younger actually.

In the 1996 field season, only small test excavations were undertaken. From first rtesults it is possible to introduce now some preliminary information and conclusions concerning the site. Here, the cultural layer is exposed along a 60 m long abraded river bank, 6-7 m high, which is supposed to be the level of the 3d (?) terrace, covered by 1 - 1.2 m thick stratified accumulation, composed of yellow or light yellow-brownish colored sandy soil. Sediments, both underlying and covering, are undoubtedly of alluvial genesis. The cultural layer has been described formerly as "peat-bog sediments". It is very solid, consisting of peat containing large number of fragmented bones. Judging by cultural remains discovered during the excavations (we excavated about 6 m^2 of cultural layer found both *in situ* and in diverse sized blocks sloping down from the edge of the river bank), the site location had been chosen in the typical, most traditional aboriginal style.

Diverse food sources such as fish, birds and reindeer were available here, but the latter was the main resource, and reindeer bones were found in a huge quantities. It could be said that the cultural layer "consists" of fragmented and crushed reindeer bones. Of course, the site location was especially favourable for reindeer hunting, and the location still has an abundance of them. During the excavations we were lucky to see uncountable numbers of reindeer moving along the river all day long. And even the name of the brook itself – "Oleny" – means "reindeer brook". Obviously the site location chosen because of the abundance of the migrating reindeer, was occupied for some periods in spring or in late summer, or both. It was neither a "kill" nor a "living" site, most likely it was a "combination" of both, as all the animals were mainly taken somewhere in the surrounding area, and then butchered and eaten at the site. The composition of reindeer bone remains supports that view: almost all categories of reindeer skeleton remains are represented including hoof phalanges and even skulls, which are almost intact (the latter – both the presence of skulls and their good condition – is rather unusual). At the same time, the vertebrae and hoof phalanges are rather rare. As mentioned above, the bones are extremely fragmented, or crushed, including the smallest such as phalanges I and II.

Due to preservation qualities of the permafrost (the layer is permanently frozen much deeper than the bottom level of the active horizon), organics including wooden pieces, bark, fish bones and scales are well-preserved. Artifacts composing the Oleny Brook site assemblage, were both excavated and collected on the beach and are mainly made of bone and antler. The collection contains artifacts which are typical of northern aboriginal sites. They include bone and antler knife handles, spearpoints and arrowheads, fragmented unilaterally barbed fish spear, worked bone and antler pieces, part of a swivel block for a sledge harness (?), and a decorated piece of bone used as a pendant (?).

Many ceramic fragments were found also. The latter represents two kinds of pottery (both thick and thinwalled) which were in use at the site. Although the inhabitants undoubtedly used metal tools as can be seen from the character of marks on the surfaces of worked bone and antler pieces (and it was iron most likely), stone tools such as axes or large scrapers were presumably in use too, since waste flakes (solid coarsed grey stone, about 20 pieces), and some pieces of raw material was found. In this way we have a composition which is rather typical of sites which are generally dated to 2,000 BP or a little younger, and this is confirmed by carbon dating. The date obtained from charcoal collected from the cultural layer is 1,880 +/- 75 BP, LE 5176 (uncalibrated age). And, it is very interesting that the location definitely was not in use for a long time even though the site area has diverse food sources available. The assemblage comprises as a whole artifacts of the most general types which can be found in any Eurasian arctic site of this period, or even later, from west to east. Some of these pieces, such as knife handles, can be found even in today's living arctic cultures. Thus, exactly the same handles as well as the multi-pointed arrowhead, similar to the unfinished one from Oleny, were excavated from Mys Vkhodnoy site located on the mainland coast opposite Vaigach Island, and from Karpova Guba site found on Vaigach. Projectile heads exactly copying one from the Oleny Brook site are known, for example, from Eskimo sites on Cape Krusenshtern, Alaska. The others, such as a harpoon point, have a stable shape for a long time. Exactly the same harpoons are known in South Siberian Mesolithic sites.

At the same time, there is one piece of special interest. This is a primitive flat swivel block which is, of course, of the very general type, too. Findings of these blocks are extremely wide-spread – from the Ust-Polui site in the West Siberia to Eskimo sites – and they were in use even at the beginning of our century. But these harness parts are of special interest because they give us evidence of sledge transportation. The only (and important) question is – of which type of sled? In the Ust-Polui site where a knife handle with a depiction of a harnessed dog was found, it probably signifies dog traction, and it was definitely dog traction in the Eskimo sites; but it remains unclear in the case of Oleny Brook site, or in the finds from Mys Vkhodnoy in the far northeastern portion of European Russia.

Although the data from the test excavations at Oleny Brook site looks is of very preliminary nature, they are nevertheless very significant – thus, the Oleny Brook site is the northernmost site ever found on the Taymyr Peninsula, and it was found in an area which was supposed to have remained unpopulated for centuries. The indiginous people inhabitting the Taymyr autonomous area today, live in the south, moving along the main rivers while the central and the northern portions of Taymyr are a sparcely populated, or almost an unpopulated territory and has been for the last three hundred years. Leonid Khlobystin, the first archaeologist exploring the area, excpected this area to have archaeological cultures of another type, in comparison with the sites studied in the southern territories. Unfortunately, there is nothing to support or to argue that view now.

2.8 A Gas-Mercury Survey in the Levinson-Lessing Lake Area

(O.M. Antonov)

The major objective of the gas-mercury survey was to reveal the modern activity of disjunctions within the framework of studies of neotectonic development of the central part of the Glavnaya Ridge of the Byrranga mountains. It was planned to reveal the emanation anomalies and zones of enhanced mercury concentration in the soil and surface air along the lines of active fractures, zones of jointing and cleavage.

- Time frame: June 27 - July 26, 1996
- The number of sampling points: 190
  representative points: 181.
- The boundaries of the work region:
  in the north: the mouth of the Zamknutaya River,
  in the south: the Protochny Stream.

The measurements were carried out along the Krasnaya and Mramornaya Rivers and the Vrezanny Stream and along the western and eastern lake coasts at a distance of 0.5-3.5 km from the coastline.

Methods

Measurements were performed by a portable mercury analyser AGP-01 (manufactured in 1991 in Yekaterinburg). Power supply is 12 V from an alkaline accumulator battery. The measurement range of the mass mercury concentration in the air was from 1.0×10^{-9} up to 9.9999×10^{-5} mg/l. The volume of the analysed air sample was equal to 0.5, 1.0, 5.0, and 10.0 l, with an error of ±10 %. The limit of the permissible systematic error is 30% of the measured value.

At each sampling point 5 measurements were made, on average, in the soil air and 2 in the atmospheric air and at the variations of readings of more than 30 % - up to 8 measurements in the soil air and 3 in the atmospheric air. At the voltage drop below the permissible level (11.5 V) the mean of two maximum readings at the given sampling point was assumed to be final. The measure-ment depth varied from 12 to 30 cm depending on the physical-mechanical ground properties. At sampling, the advantage was given to more fine-grained grounds since in the rock-debris-gruss and pebble-gravel deposits there is active diffusion of the soil and atmospheric air which underestimates the true readings of the analyser.

A significant limitation in the work was the temperature regime. Low temperatures (less than 4°C) and relative humidity of more than 90 % led to a rapid discharge of accumulator batteries. The choice of the sampling points was governed by the following factors:

- Position and character of disjunctions,
- a plan contour of linements identified from aerial photography and the digital relief model,
- the character and intensity of the errosion downcutting,
- data of hydrochemical, bedrock and heavy concentrate sampling,
- composition and thickness of Quaternary deposits, and
- composition of bedrock.

Preliminary Results

Mean content of mercury in the study region is 67.8 ppm, with a maximum of 300 ppm (downstream the Vrezanny Stream) and a minimum of 20 ppm (on the first terrace above the flood-plain in the Krasnaya river mouth; Fig. 2-61). By the background content of mercury, the region can be clearly divided into two parts - the north-eastern and the south-western. The north-eastern is characterized by mean background values of about 48 ppm and the south-western of about 72 ppm. The enhanced background southward is explained by the increased modern tectonic activity in the direction of the Taymyr depression.

The north-eastern part is characterized by a steady geochemical background varying within 30 to 60 ppm. The maximum values (more than 100 ppm) are observed only in the central part of the massifs of carbonate metasomatites (D_2-C_1) east-northeast of the Krasnaya River mouth - 126 ppm and 103 ppm as well as at the accumulation lake terrace of the Levinson-Lessing Lake within the same massif. Although the zone of increased concentrations coinsides by strike with the massif of carbonates, the enhanced values are, probably, not connected with the substance composition of rocks, since the identical by composition carbonate metasomatites in the region of left tributaries of the

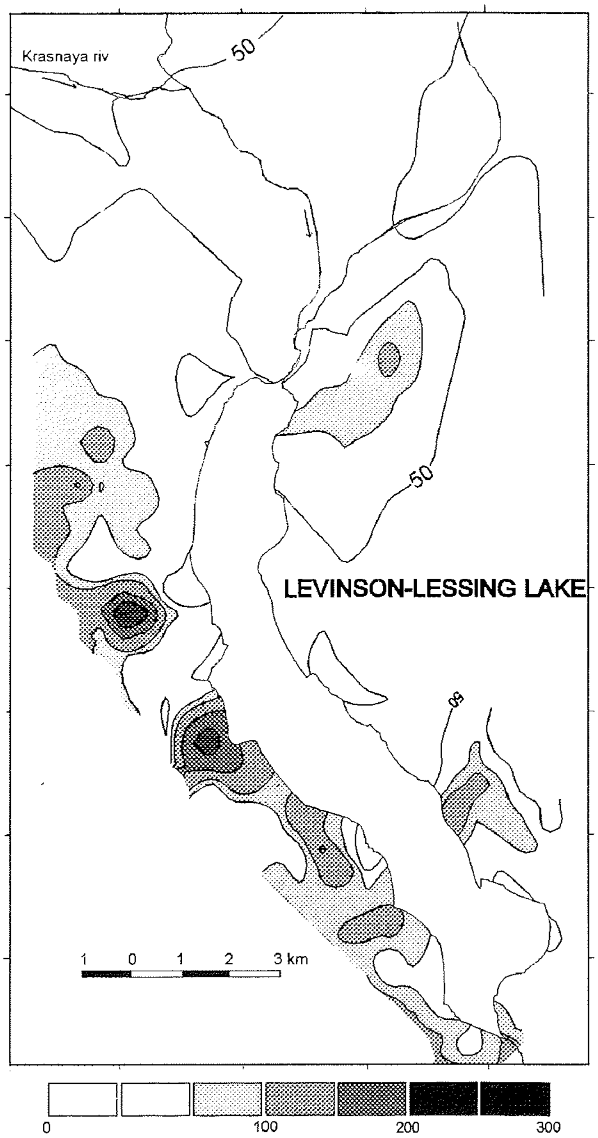


Figure 2-61: Mercury concentration in soil air (ppm mg/l).

middle current of the Mramornaya River (northern part of the massif) have concentrations of 36-41 ppm. The fractures restricting the massif in the structural plan are not pronounced in the geochemical field, thus indicating their small modern activity. Same can be said about the thrust of the tuff-lava covers in the middle stream of the Krasnaya River above the mouth of the Zamknutaya River. Small increases in concentration up to 70 ppm (the Krasnaya River flood-plain) and 68 ppm (the debris cone on the left bank of the Krasnaya River) are observed along the latter.

The southern part is characterized by a distinct increase in concentrations in the soil air in the thalwegs of the young erosion downcutting and the decrease up to background values at the watersheds. The valley of the Vrezanny Stream is a characteristic example. Its left slope presents a tectonic bench up to 400 m high. Downstream, the concentrations vary within 119-162 ppm reaching the maximum of 300 ppm in the near-top part of the Vrezanny Stream delta. The stream valley is located along the sublatitudinal fracture which is considered a branch relative to the deep fracture of the Levinson-Lessing Lake. The emanation activity of the deep fracture is revealed in enhanced concentrations in the valley of the Protochny stream - 125 ppm.

The geochemical activity was recorded in a number of small young valleys confined to the growing vault uplift at the south-western coast of the Levinson-Lessing Lake. Whereas at the watersheds and in the mouth areas of valleys the concentrations are 26 to 62 ppm, in thalwegs they reach 143 ppm and 168 ppm. The increase in the concentrations is observed along the central part of the western coast of the lake where along the solifluction slopes of the foot train the maximum values are equal to 145 ppm and 264 ppm. On the south-eastern shore of the lake in thalwegs of the valleys of east-north-eastern orientation the content of mercury in the soil air reaches 102-141 ppm. The spatial position of the valleys in direct proximity from the regional fracture suggests their location along the system of young cracks brahcning from it.

Main Conclusions

Data of gas-mercury survey suggest the following:

(1) The plan position of the zones of elevated concentration and anomalies is governed, primarily by modern emanation activity of disjunctions, rather than by the substance rock composition. This is proved by the absence of any significant concentrations of mercury-containing minerals in heavy concentrates and rock samples in the zones of anomalies.

(2) Activity of main disjunctions is mainly manifested along the jointing zones and fractions without displacement branching from them. This is, probably, correct both for the north-eastern and south-western parts of the region. Of obvious fractures, data of the gas-mercury surveys directly confirm the fractures along the Vrezanny and Protochny Streams and with a lesser assurance the thrust along the Krasnaya River.

(3) The chain of local anomalies along the western shore of the lake is governed by the position of the deep fracture of the Levinson-Lessing Lake. Based on this fact, one may suggest its strike in the northern part of the region to the north-northwest along the valley of the right tributary of the Skalisty Stream and, probably, farther along the valley of the Ozerny Stream valley. For the southern active part of the fracture, the south-westward plane dip at a greater angle is probable.

(4) The southward increase in the background content of mercury is attributed to modern activity of the structures spatially and genetically related to the opening of depressions of the Ledyanaya Inlet and the Taymyr Lake.

3 INVESTIGATIONS ON SEVERNAYA ZEMLYA

3.1 Pedological and Biological Studies

3.1.1 Introduction

(M. Bölter, E.-M. Pfeiffer, M. Zhurbenko, S. Aparin, T. Müller-Lupp)

General features - The archipelago of Severnaya Zemlya belongs to the Eurasian polar belt. Its main islands - Pioneer, Komsomolets, October Revolution, and Bolshewik - are the most northern part in the Siberian polar deserts province of the Russian Federation. The region is ecologically related to the area of Cape Chelyuskin on the north of Taymyr Peninsula. The archipelago can be seperated into two different areas by climatological and botanical aspects: into a northern belt with the islands of Komsomolsk, Pioneer and Sredny and into a southern belt with the islands of October Revolution and Bolshewik (Alexandrova 1988). The main difference between the belts is characterized by the temperature: the warmest month in the northern belt does not exceed 1 °C, whereas the southern belt may reach in this respect 1-2 °C (Semenov 1966b).

Climate - Low energy input from sun and low precipitation, although exceptions with foehn winds have been monitored which have also resulted in some extrazonal conditions for plants and soil developments (Korotkevich 1958, Safranova 1976). Details of climatological conditions for this region were summerized by Prik (1970) and Korotkevich (1972). Strong winds during winter and spring lead to low snow accumulation. The snow cover is only about 40 cm or less (Semenov 1970). This leads to a limitation of water supply and a reduced shelter of the plants. The summer precipitation does not exceed 60 mm (Mikhaylov 1960). The microclimatic conditions also remain severe and temperature at soil surfaces with different plant covers do not exceed 4-6 °C of air temperature (Chernov et al. 1979).

Soils - The soils of Severnaya Zemlya show limited development and weak profile differentiation. Typical are stoney surface patterns with arctic desert soils or arctic tundra soils (Pfeiffer et al. 1996). The amount of skeletal material is higher than the fine earth. Erosion and mostly physical weathering are the dominant processes, while chemical and biological processes are less important (Alexandrova 1988). This means that fine silt and clay are not the result of *in situ* weathering but transported by wind or water to their recent deposits. Patterned grounds - like sorted circles, nets and polygons - are widely spread in this region. Because of the low soil water content, due to the cold aridic climate (Mikhaylov 1970), small amounts of fine earth and short times of appropriate temperature changes the polygones renain relatively small in diameter: about 50 cm or less (Korotkevich 197). As such, Matveyeva (1979) described polygone abundances in the region of the polar desert of Cape Cheleyuskin with 400 polygons per 100 m^2, in the arctic tundra region only 100 polygones per 100 m^2.

While the centers of the polygones are often uncovered or only weak covered by plants, the border and fissures are mostly covered with mosses and vascular plants. Opposite to subarctic tundra environments where peat soils are very common, the polar deserts have been developed histic horizons only in very wet microrelief positions (small depressions, troughs, see Chapter 3.1.2.1). Fulvic acids dominate in the humic substances and the gleyzation occurs only in the southern areas of the polar deserts as an extrazonal phenomenon (Chugunova 1979). In the northern parts this process occurs only under mosses with high water saturation (Govorukha 1970).

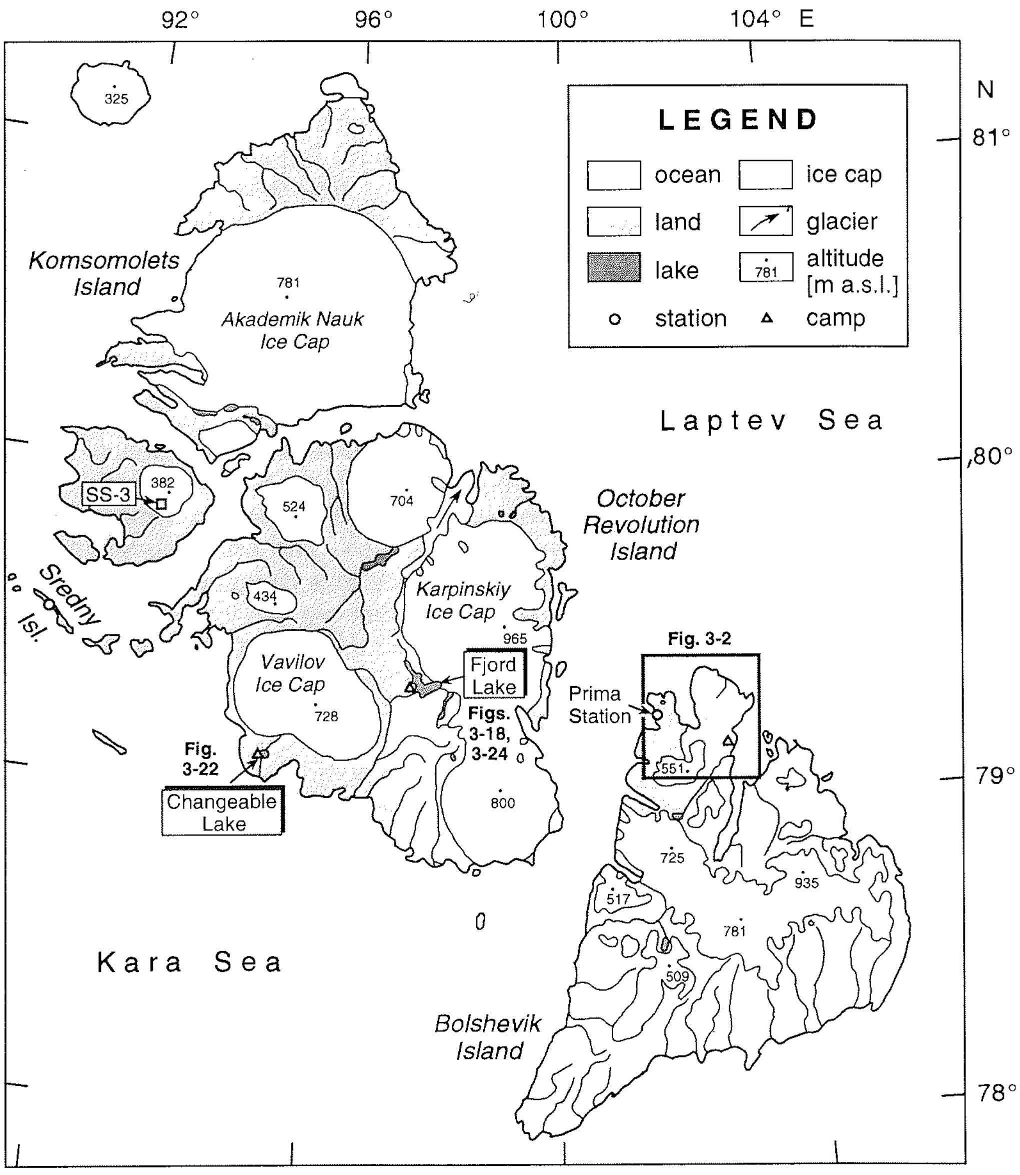


Figure 3-1: Map of Severnaya Zemlya showing expedition sites 1996 (for large-scale overview see Fig. 1-1).

Vegetation - Some vegetation descriptions of Severnaya Zemlya are given by Korotkevich (1958), Safranova (1976, 1981), Khodachek (1980), and Matveyeva (1979). Dominant features are the lack of wooden species and the low share of vascular plants. Vascular plants do not form a consistent cover but grow individually. They do not have contact with each other in the root system. This is one main fact for differentiating the polar deserts from the tundra (Alexandrova 1988). For wide areas the cover of vascular plants does not exceed 3-7 % (at cape Chelyskin, Matveyeva 1979). Alexandrova 1988 describes this as nanocomplexes, nanophytocoenoses, which may form semi-aggregations. However, they have to be considered as active units which affect the surface soils, also in terms of soil development. The dominant plants in this region are lichens and mosses. Bölter and Kanda (in press) and Kanda (1996) have presented preliminary reports of vegetation patterns of Komsomolsk, October Revolution, and Bolshewik Islands. Vegetation patterns more similar to tundra types (cold semi deserts) have been found in the southeastern part of October Revolution Island by Korotkevich (1958) and Safranova (1976) due to azonal climatological conditions, which was also proposed for areas at Bolshewik Island leading to "oases" which support growth of very small shrubs, namely *Salix polaris* (Korokevitch 1972).

Microfauna and microflora - The microfauna and microflora have been found specific for this region. They are dominated by cyanobacteria, non-spore forming bacteria and actinomyces (Sushkina 1969, Novichkova-Ivanova 1963, 1973). Further, soil micromycetes were isolated from polar deserts (Kirtsidely 1996, Zhurbenko & Kirtciteli 1996). Nematodes, collemboles, enchytridae and larvae of chironomides were found in these soils (Matveyeva & Chernov 1976).

3.1.2 Soil-Plant-Complexes on Bolshewik Island

(E.-M. Pfeiffer, S. Aparin, M. Zhurbenko, M. Bölter, T. Müller-Lupp)

Soil and vegetation studies were done during July expedition 96 on typical sites of the northern peninsula with Cap Baranov of Bolshewik Island. Two areas were investigated by soil and plant description: the main investigation area is located near the polar station "Prima" at the eastern coast of the Shalskogo Strait (Fig 3-1). A second part of the island has been investigated in a 3 days field camp near the western coast of Akhmatova Bay and ca. 9 km southwest of the Bazovaia River (Fig. 3-2). A complete mapping of the soils was not possible, but the described 10 sites represent the most common soil-plant-complexes of the northern part on Bolshewik Island. The patterned grounds (surface structures, microrelief, surficial geomorphology) are described according to Washburn (1979). The soil features and properties are determined according to guidelines of FAO (1988) and Soil Survey Staff (1994). The russian system of Gerasimova et al. (1996) and of the Soil Survey Staff (1994) are used for the soil classification. Soil monoliths are taken of 4 typical patterned grounds around Prima Station, they will be exhibited in the Central Museum of Soil Research of St. Petersburg. The site locations were measured by GPS.

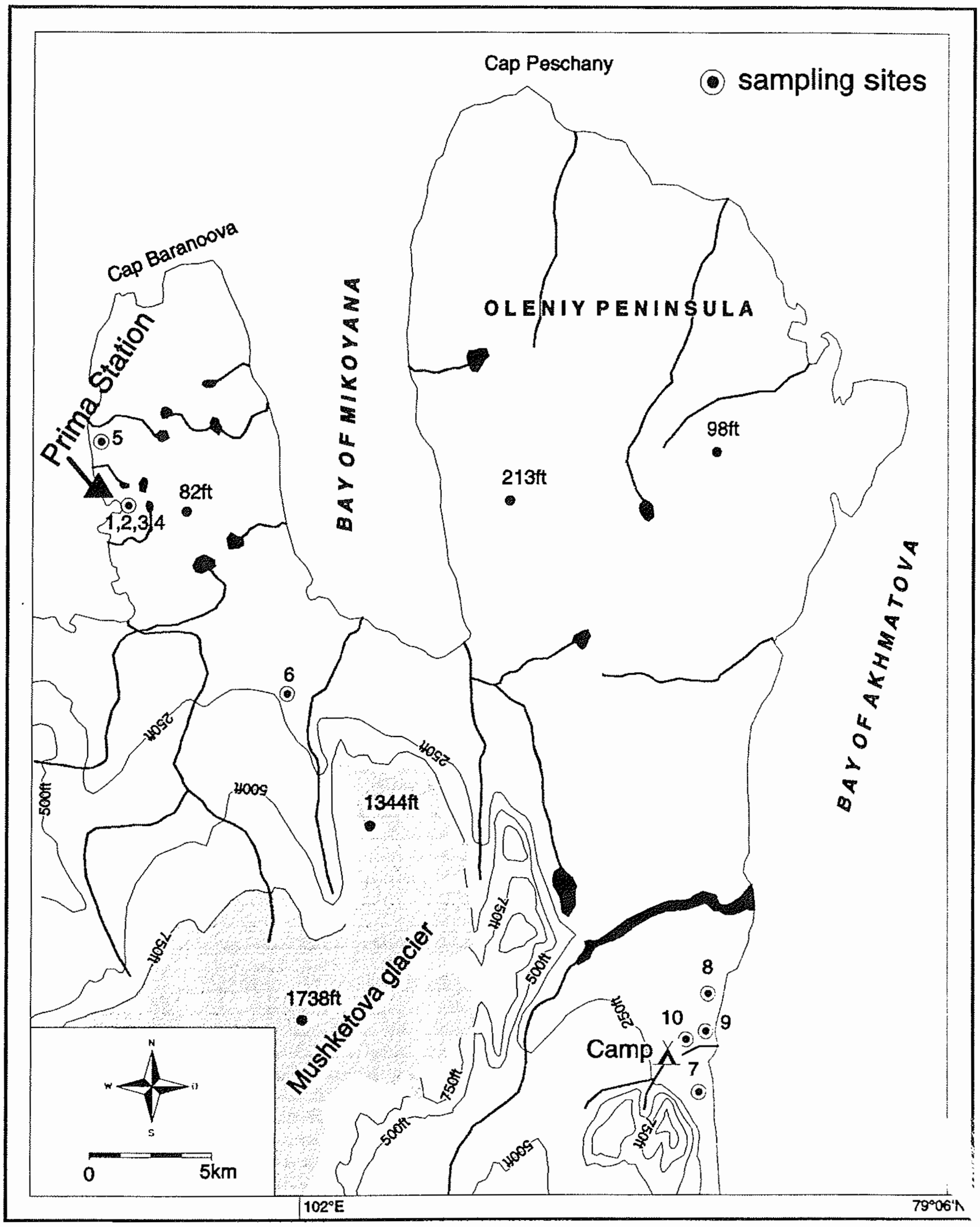


Figure 3-2: Map of pedological and biological sampling sites on Bolshewik Island.

3.1.2.1 Soils and Patterned Grounds

(E.-M. Pfeiffer, S. Aparin, T. Müller-Lupp)

The soils of northern Bolshewik Island together with the vegetation form special surface structures which could be divided in two main types: Sparcely vegetated arctic desert soils with weak patterned grounds and well developed surface structures with arctic tundra soils and a differentiated plant cover.

The main patterned grounds are nonsorted and sorted nets. Soils are dominated by lithogenic properties caused by the extreme rock characteristics, by erosion processes and by the cold climate conditions. The soil formation processes are dominated by physical weathering. The main parent materials are the debris of clay schists and sandstones. The weak horizont differentiation is mostly characterized by humus accumulation. In wet and well protected microrelief positions (depressions, troughs, fissures) organic surface horizons (O layers, weak histic epipedons) are formed. The soil moisture regime has two extremes: In exponated positions soils are dry due to low precipitation input and drying by wind influence. In depressions and on wet slope sites aquic conditions form hydromorphic features with free reduced iron and typical mottles which are typical for gley horizons. The main soil types are Pergelic Cryorthents and Cryaquepts. The active layer has an average thickness of 34 cm - due to the texture and the water status. At very coarse stony sites the permafrost table is not found within 65 cm soil depth.

Surprisingly, relatively high percentages of plant cover are determined on the 10 sampling plots (10 m x 10 m): about 20 - 48 % of the soil surface was covered by plants. On the climatically favoured plot of site 9 (Fig. 3-15) - on moist and fine textured soils near the shoreline of Akhmatov Bay on the east coast of Bolshewik Island - a maximun plant cover of up to 90% was found. Soils and typical plants are sampled for C-fractionation and isotope analysis. Soil and plant data are used to compare the soil developement on the different subarctic and arctic tundra sites on Taymyr Peninsula and Severnaya Zemlya.The list of the 10 sampling sites (Figs. 3-4 to 3-17) describes the main soil types according to Soil Survey Staff (1994) and the patterned ground types according to Washburn (1978):

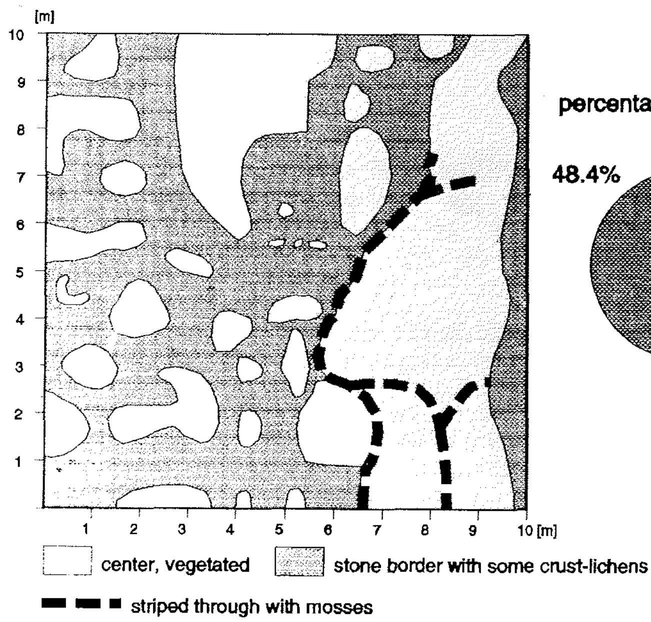


Figure 3-3: Soil surface structure (sorted nets) and percentage of plant cover of site 1 on Bolschewik Island (Fig. 3-4, see following page).

Site 1: Pergelic Cryorthent of Sorted Nets

location:	Severnaya Zemlya, NW of Bolschewik Island, 79°16,55´ N, 101°39,42´ E
landscape:	flat elevation/ terrace of medium and coarse gravels, stone boulders
elevation:	20 m a.s.l.
vegetation:	moss-lichen polygonal gravel-stony tundra
permafrost-table:	under center 35-40cm; under stone border 30cm
parent material:	debris of clay schist and sandstone
soil water state:	slightly dry (moist) on surface, temporary moist during snowmelt
soil-profile:	1a: Ai - AB - Bw - C; 1b: Ai - BC - Cw - Cf
russian system:	arctic desert polygonal sandy loamy, underlain by permafr.

Horizont	depth [cm]	description
1a A	0-2	medium sand with 40% flat/angular fine and medium gravel, 10YR2/2
AB	2-10	medium sand with >80% flat/angular medium and coarse gravel, 10YR3/2
Bw	10-30	medium sand with 75% subrounded fine gravel, 10YR3/3
Cw	>30	medium sand with >80% subrounded medium gravel, 2.5YR3/1
1b Ai	0-2	medium sand with 40% flat/angular fine and medium gravel, 10YR1/2
Bw	2-30	loamy sand with 5% angular/subrounded coarse gravel, 10YR3/3
Cw	30-40	loamy sand with 65% subrounded medium gravel, 2.5Y3/2
Cf	>40	frozen sand with >80% subrounded fine and medium gravel, 5Y4/1

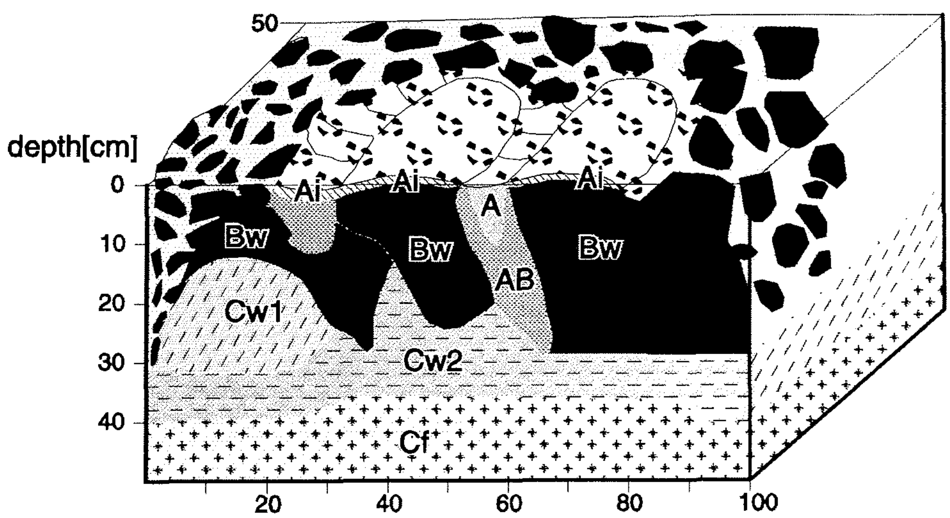


Figure 3-4: Soil profile of site 1: Pergelic Cryorthent/Sorted Nets.

Site 2: Pergelic Cryorthent of Nonsorted Circles

location:	Severnaya Zemlya, NW of Bolschewik Island; 79°16,46′ N, 101°39,87′ E
landscape:	marine terrace near shoreline of Shokalskogo Strait
microrelief:	circles and nets of fine-medium gravels
vegetation:	lichen-moss-herb-polygonal sparse tundra (*Eritrichium villosus = Forge-Me-Not)*
permafrost-table:	>65cm
parent material:	debris of clay schist and sandstone
soil water state:	dry, sureface dry by wind
soil-profile:	2a: Bw1 - Bw2 - Cwf; 2b: O - A - Bw - Cwf
russian system:	arctic desert fractured-polygonal sandy loamy with indications of cryoturbation, underlain by permafrost.

Horizont	depth [cm]	description
2a Bw1	0-17	sandy loam with 20% flat/subrounded medium and coarse gravel, 10YR4/3, single grain structure
Bw2	17-50	loam with 15% flat/subrounded fine and medium gravel, 10YR5/3
Cf	>50	frozen loam with 30% subrounded medium and coarse gravel, 10YR4/3
2b O	2-0	10Yr4/3, with 15% flat/angular medium and coarse gravel.
A	0-30	sandy loam with 25% flat/subrounded medium and coarse gravel, 10YR3/2
Bw	30-65	sandy loam with 15% subrounded fine and medium gravel, 2.5Y4/3
Cf	>65	frozen loam with 30% subrounded fine and medium gravel, 10YR4/3

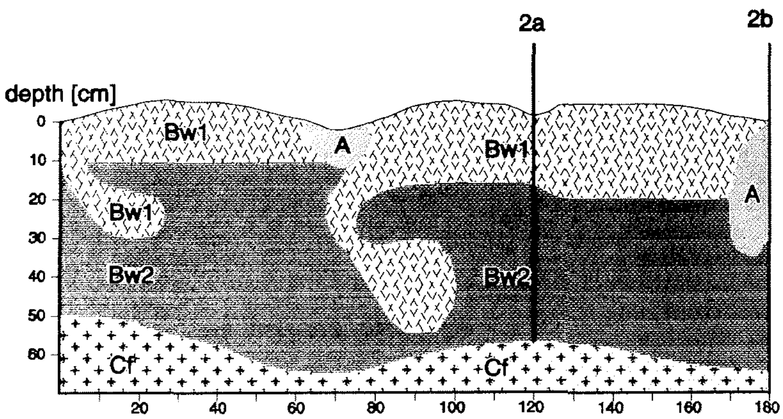


Figure 3-5: Soil profile of site 2: Pergelic Cryorthent/Nonsorted Circles.

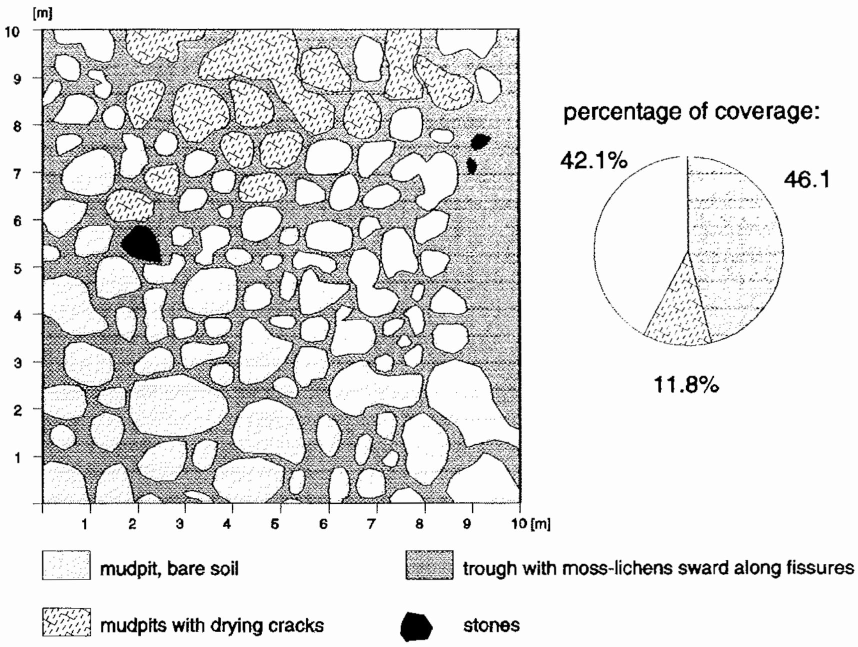


Figure 3-6: Soil surface structure (nonsorted circles) and plant cover of site 2 on Bolschewik Island (see Fig. 3-5, previous page)

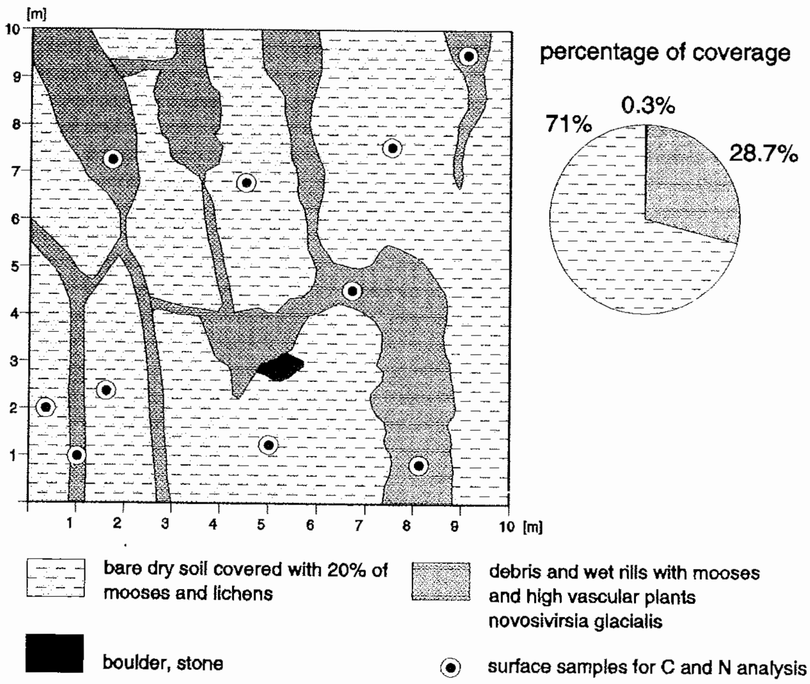


Figure 3-7: Soil profile of site 3: Humic Pergelic Cryaquept/ Sorted Stripes on Bolshewik Island (see Fig. 3-8, following page)

Site 3: Humic Pergelic Cryaquept of sorted stripes

location:	Severnaya Zemlya, NW of Bolschewik Island; 79°16,37´ N, 101°39,97´ E
landscape:	flat slope of the second terrace
vegetation:	moss-herb stony-gravel-stripe tundra (*Novosiviersia gacialis)*
permafrost-table:	>35cm
parent material:	debris of clay schist and sandstone
soil water status:	wet, very wet in runways and microdepressions along the slope
soil-profile:	3: A1 - A2 - Bg - BC
russian system:	arctic desert slightly sand loamy, underlain by permafrost.

Horizont	depth [cm]	description
3 A1	0-2	sandy loam with >80% flat/subrounded fine andmedium gravel, 10YR2/1
A2	2-10	sandy loam with 65% subrounded medium gravel, 10YR3/2, single grain structure
Bg	10-25	loam with 40% subrounded fine andmedium gravel, 5Y3/1, pos. reaction of αα-Dipyridyl
BC	>25	silt loam with 15% subrounded fine gravel, free water

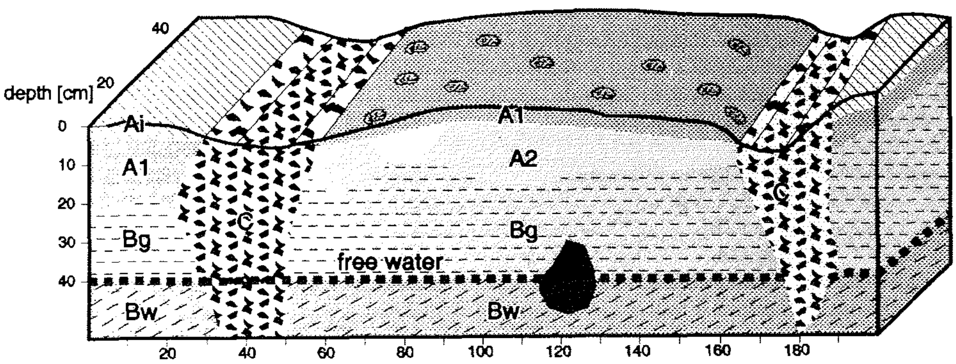


Figure 3-8: Soil surface structure (sorted stripes) and plant cover of site 3.

Site 4: Typic Cryaquent of spots of vegetation (weak non-sorted nets)

location:	Severnaya Zemlya, NW of Bolschewik Island; 79°16,32´ N, 101°40,35´ E
landscape:	gently inclined slope of coastal terrace
vegetation:	lichen-moss-grass spotty tundra (small tussocks of *Deschampsia glauca)*
permafrost-table:	34cm
parent material:	debris of clay schist and sandstone
soil water status:	wet, very wet only during the snowmelt
soil-profile:	4: Ai - Bw - Cf
russian system:	arctic desert clay, underlain by permafrost.

Horizont		depth [cm]	description
4	Ai	0-2	silty clay with 30% flatmedium and coarse gravel, 10YR3/2
	Bw	2-34	clay with 45% angular/subrounded medium gravel, 2.5Y4/2, pos. reaction of aa-Dipyridyl
	Cf	>34	clay with 45% angular/subroundedmedium gravel, 2.5Y4/2, pos. reaction of aa-Dipyridyl

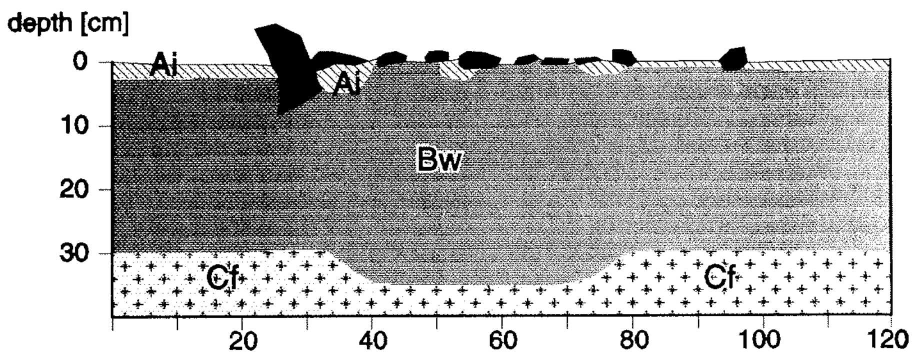


Figure 3-9: Soil profile of site 4: Typic Cryaquent of weak nonsorted nets/ spots of vegetation

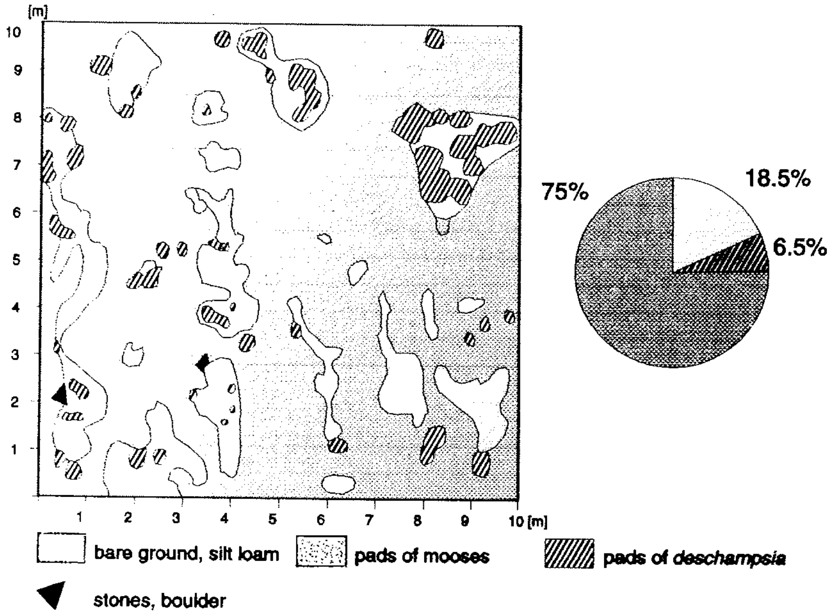


Figure 3-10: Soil surface structure (spots of plants / weak nonsorted nets) and plant cover of site 4 on Bolschewik Island (see Fig. 3-9, previous page).

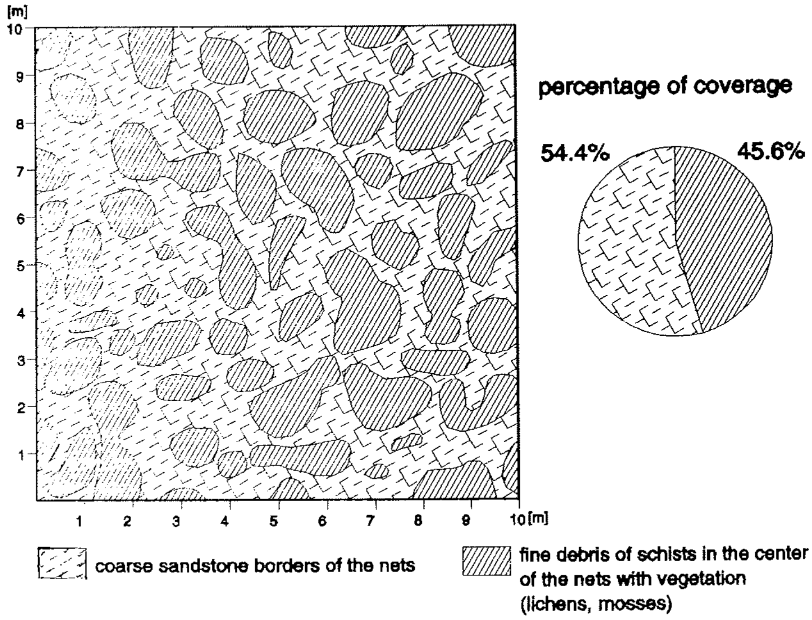


Figure 3-11: Soil surface structure (sorted nets) and plant cover of site 6 on Bolschewik Island (see Fig. 3-13, two pages forward).

Site 5: Typic Cryaquent of weak nonsorted nets

location:	Severnaya Zemlya, NW of Bolsch. Isl.; 79°17,34´ N, 101°36,85´ E
landscape:	upper part of slope on coastal terrace north of Prima Station
vegetation:	lichen-moss-grass spotty tundra (Papaver polare, *Desch-ampsia glauca)*
permafrost-table:	30 cm
parent material:	fine sediments of clay schist
soil water status:	wet, very wet only during the snowmelt
soil-profile:	5: Ai - Bw - Cf
russian system:	arctic desert clay, underlain by permafrost.

Site 5 is comparable with the soil-plant complex of site 4. No detail description and no sampling have been done.

Site 7 : Humic Pergelic Cryaquept of Sorted Nets

location:	Severnaya Zemlya, NE of Bolschewik Island; fieldcamp 9 km S of Bazovaia River; 79°04,02´ N, 102°42,02´ E
landscape:	moderately inclining terrace near coast of Akhmatov Bay
vegetation:	moss-herb polygonal gravel-stony tundra (tussocks of Novosieversia glacialis)
permafrost-table:	> 35cm
parent material:	coarse debris of sandstone
soil water status:	moist, wet during snowmelt
soil profile:	7: O1 (0-5cm) - O2 (5-16cm) - Cw (16-20cm) - Cf
russian system:	arctic tundra peaty slightly sand loamy underlain by perma-frost

The detail description will be presented elsewhere. The O-horizons and the fresh plant material of Novosieversia was sampled for C-analysis.

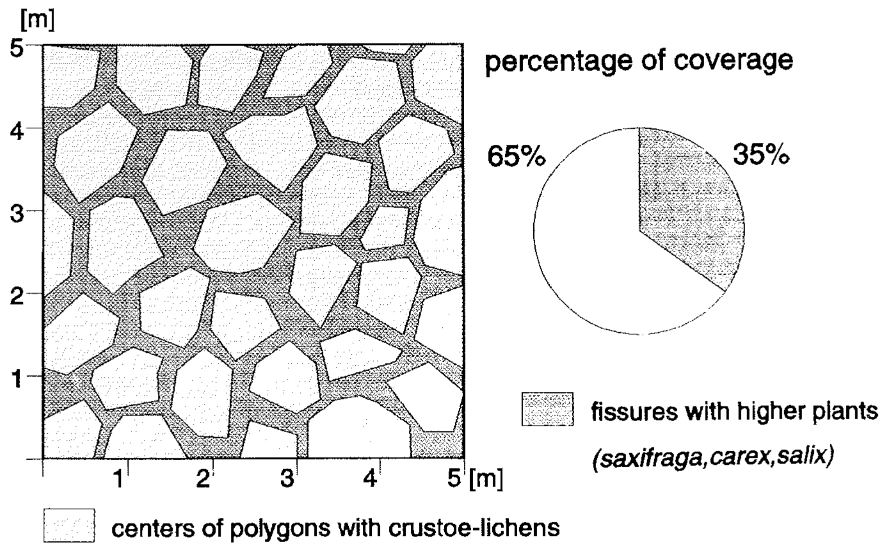


Figure 3-12: Soil surface structure (small polygones) of site 8 on Bolschewik Island (see Fig. 3-14 see 2 pages forward).

Site 6: Pergelic Cryorthent of sorted nets (big stony poly-gons)

location:	Severnaya Zemlya, N of Bolschewik Island; 79°11,02´ N, 102°09,02´ E
landscape:	old moraine plain in front of the Mushketova Glacier
vegetation:	moss-lichen polygonal gravel-stony tundra
permafrost-table:	45-50cm
parent material:	debris of clay schist and sandstone
soil water status:	dry
soil profile:	6a: A - Cw1 - Cw2 - Cf; 6b: A - ABw - Cw - Cf
russain system:	arctic desert sandy loamy underlain by permafrost.

Horizont	depth [cm]	description
6a Ai	0-2	medium sand with 40% flat/subrounded fine andmedium gravel, 2.5Y2.5/1
Cw1	2-34	fine sand with >80% subrounded medium and coarse gravel, 2.5Y4/1
Cw2	34-50	loamy fine sand with 40-80% subroundedfine and coarse gravel, 2.5Y4/2
Cf	>50	fozen fine sand
6b Ai	0-2	fine sand with 15% subrounded fine and medium gravel, 10YR3/1
Bw	2-13	fine sand with 40% subrounded fine and medium gravel, 10YR3/3
Cw1	13-35	medium sand with >80% gravels, 2.5Y4/1

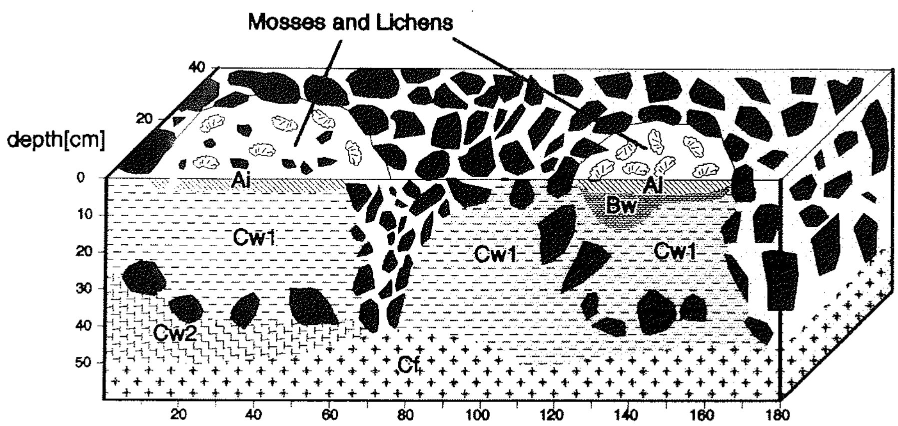


Figure 3-13: Soil profile of site 6: Pergelic Cryorthent / Sorted Nets.

Site 8: Pergelic Cryaquept of Nonsorted Nets (small poly-gons)

location:	Severnaya Zemlya, NE of Bolschewik Island, field camp 9 km S of Bazovaia River, 79°04.10´ N, 102°41.20´ E, 200 m from coast line
landscape:	moderately slope of the first coastal terrace
vegetation:	lichen-herb small-polygonal tundra: crustoe lichens on centers, in the fissures vascular plants like *Carex arctisibiria, Salix polaris, Saxifraga spec.*
permafrost-table:	25 cm
parent material:	marine loamy fine sand
soil water status:	moist, wet during snowmelt
soil-profile:	8: OA -Ah - Cg1 - Cg2 - Cg3
russian system:	arctic tundra gley heavily sand loamy, underlain by permafrost.

Horizont	depth [cm]	description
8 OA	0-2	crustoe lichens on loamy fine sand
Ah i	2-11	loamy fine sand, 10YR4/4
Cg1	11-20	loamy fine sand, 5Y6/1
Cg2	20-25	loamy fine sand, 10YR5/6
Cg3	>25	loamy fine sand, 5Y5/2, pos. reaction of aa-Dipyridyl

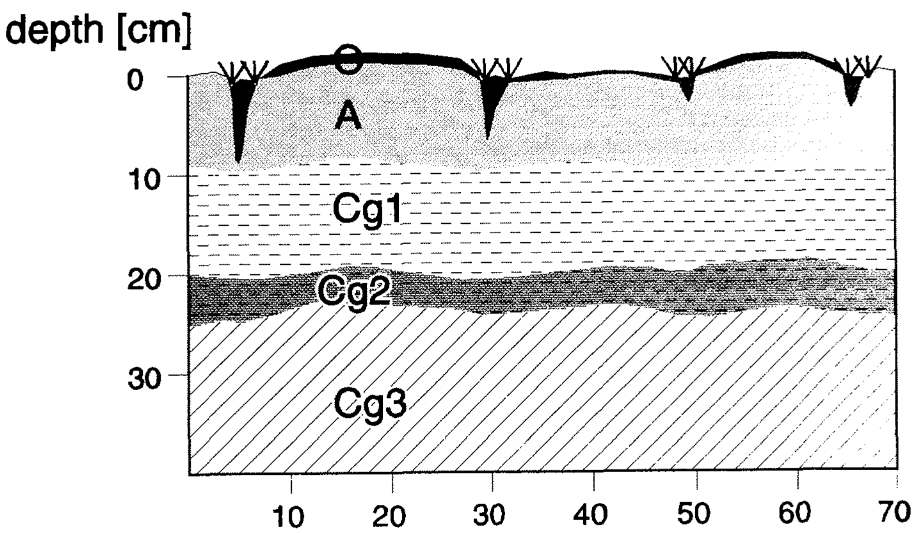


Figure 3-14: Soil profile of site 8 (small polygones) on Bolshewik Island.

Site 9: Pergelic Cryaquept, no patterned ground (small tussocks), arctic tundra site with 90% cover of vegetation

location:	Severnaya Zemlya, NE of Bolschewik Island, 79°04,42´ N, 102°44,89´ E
landscape:	last terrace before the coastline
vegetation:	lichen-moss-grass tundra (tussocks of *Carex* spec., *Deschampsia spec.)*
permafrost-table:	46cm
parent material:	silt- and sandstone sediments
soil water status:	very wet
soil-profile:	9: A - Bg1 - Bg2 - Cf
russian system:	arctic tundra gley, silty-loamy,underlain by permafrost.

Horizont	depth [cm]	description
9 A	0-4	silt loam with 20% flat fine andmedium gravel, 10YR5/2, pos. reaction of aa-Dipyridyl
Bg1	4-17	silt loam with 30% flat fine and medium gravel, 2.5Y7/1, strong reaction of aa-Dipyridyl
Bg2	17-46	silt with 45-60% flat/angular medium and coarse gravel, 2.5Y5/1, free water
Cf	>50	frozen silt with 60% angular/subrounded medium and coarse gravel, 2.5Y4/1

Figure 3-15: Soil profile of site 9 (small tussocs) on Bolshewik Island

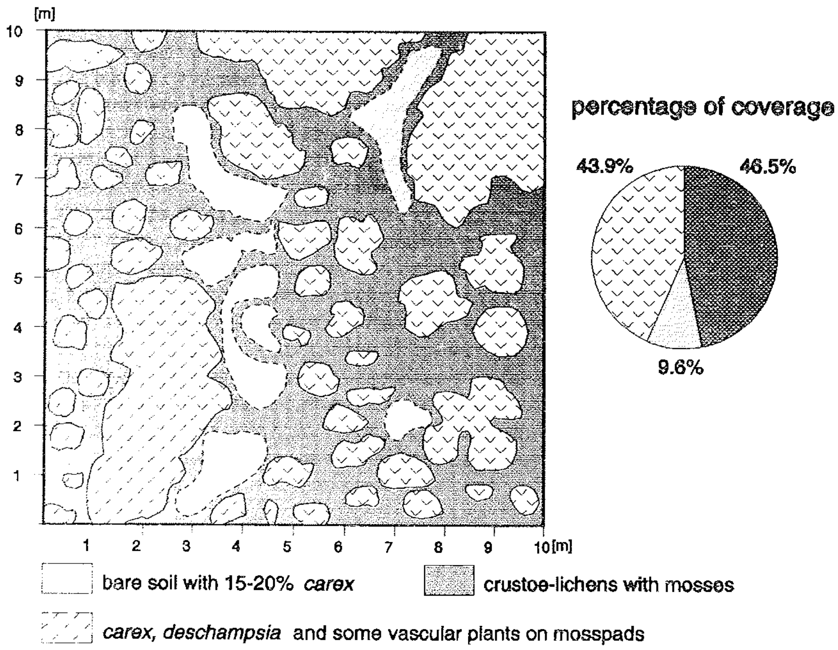


Figure 3-16: Soil surface structure (tussock like and plant cover of site 9 on Bolschewik Island; patterned ground: none (see above).

Site 10: Humic Pergelic Cryaquept of wet micro depres-sions on weak sorted nets

location:	Severnaya Zemlya, NE of Bolschewik Island, 79°04,20´ N, 102°42´ E
landscape:	flat plain of second terrace, protected micro depression with vegetation and humus accumulation, spot of 1 - 2 m in diameter
vegetation:	herb-grass- moss tundra (*Deschampsia, Dryas spec, Saxi-fraga spec, Novosiviersia glacialis*, lichens)
permafrost-table:	17cm under center, 36cm under border of the spot
parent material:	debris of slate clay and sandstone
soil water status:	moist - wet
soil-profile:	10: O1 - O2 - A1 - A2 - BCf
russian system:	arctic tundra peaty sandy loam, underlain by permafrost.

Horizont		depth [cm]	description
10a	O1	0-4	nearly uncomposed plant material (mosses dominant)
	O2	4-9	partially decomposed moss material
	A1	9-17	fine sand with 45% flat/angular fine andmedium gravel, ice lenses
	A2	17-26	coarse sandy loam with 30% subrounded fine andmedium gravel, pos. reaction of aa-Dipyridyl, ice lenses
	BCf	>36	coarse sandy loam with 65% subrounded medium and coarse gravel, ice-lenses

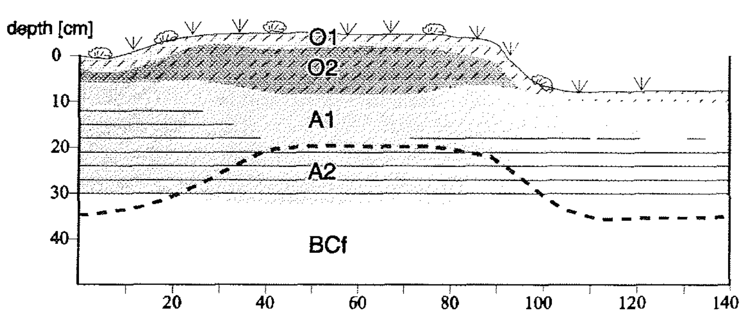


Figure 3-17: Soil profile of site 10: micro depression with humus accumulation.

3.1.2.2 Vegetation on Typical Patterned Grounds
(M. Zhurbenko)

In the zonal respect the vegetation falls within high-arctic tundras subzone of tundra zone. List of joint sampling sites:

Site 1 (1996.7.10.2): bryophyte-lichen polygonal gravel-stony tundra

Location: 79°16′ N, 101°40′ E, alt. c. 20 m a.s.l.,
Severnaya Zemlya, NW extremity/part of Bol'shevik Island, peninsula with cape Baranova, eastern coast of Shokal'skogo Strait, c. 1 km SE from "Prima"/"Mys Baranova" polar station, c. 400 m from the strait coast.

Topographic position: flat top of hill/terrace.

Surficial geomorphology: polygons consisting of: 1) 50% - spots of medium and coarse gravels with sand; 2) 50% - stripes of stones and boulders (sandstone).

Moisture status: mesic =0

Microsites:

1) Sand and gravel spots: live cover - 90%: vascular plants - +, bryophytes - 40%, lichens - 50%, some most common spp.: Sphaerophorus fragilis, S. globosus, Parmelia mphalodes, Ochrolechia frigida, Cetraria nigricans, Stereocaulon spp.; some other spp.: Papaver polare, Luzula nivalis, Novosieversia glacialis; Solorina crocea, Cladonia spp., Plectoria ochroleuca, A. nigricans, Thamnolia spp., Bryoria sp., Ochrolechia sp., Flavocetraria nivalis, Lecanora epibryon, Arctoparmelia sp., non-living cover - 10% : sand + medium and coarse gravels.
2) Stone and boulder stripes: live cover - 75% : bryophytes - ?, saxicolous and terricolous macro-lichens - 50% , saxicolous micro-lichens - 25%, some most common spp.: Sphaerophorus fragilis, Umbilicaria spp., Arctoparmelia incurva; Racomitrium lanuginosum, some other spp.: Alectoria ochroleuca, Flavocetraria cucullata, F. nivalis, Cladonia spp., Cetraria islandica, Cetraria hommixta /hepatizon, Pseudephebe spp., Brodoa sp., Bryoria sp., Peltigera sp. Non-living cover - 25% : stones + boulders.

Site 2 (1996.7.10.3): lichen-graminoids-forb-bryophyte polygonal sparse tundra

Location: 79°16′ N, 101°40′ E, alt. c. 20 m a.s.l.,
Severnaya Zemlya, NW extremity/part of Bol'shevik Island, peninsula with cape Baranova, eastern coast of Shokal'skogo Strait, c. 1 km SE from "Prima"/"Mys Baranova" polar station, c. 400 m from the strait coast.

Topographic position: flat top of hill/terrace.

Surficial geomorphology: net of micro-depressions/ditches and micro-protuberances.

Surficial geology: silt/loam - 50%, medium and coarse gravels - 50%.

Moisture status: xeric=-1, drainage! + exposed to winds - dry by winds.

Live cover: 10% (associated with micro-depressions): vascular plants - 3%, bryophytes - 5%, lichens - 2%, non-living cover: 90%.

Microsites:

1) Micro-depression: some most common spp.: Salix polaris, Eritrichium villosum, Alopecurus alpinus; Stereocaulon alpinum, Thamnolia spp.,

Peltigera spp., Physconia muscigena, Sphaerophorus globosus, Parmelia omphalodes, some other spp.: Saxifraga cespitosa, Papaver polare, Novosieversia glacialis; Flavocetraria cucullata, Cladonia spp., Cetraria islandica, Alectoria nigricans, Psoroma hypnorum, Nephroma expallidum, Megaspora verrucosa, Ochrolechia frigida, Lecanora epibryon, Hypogymnia subobscura; Aulacomnium turgidum, Distichium capillaceum.

2) Micro-protuberances: some occurring spp.: Eritrichium villosum; Pseudephebe spp., Stereocaulon sp., Physconia muscigena.

Site 2 (1996.7.13.3, analogous 1996.7.10.3): lichen-forb+grami-noid-bryophyte polygonal tundra

Location: 79°16´ N, 101°40´ E, alt. c. 20 m a.s.l.,
Severnaya Zemlya, NW extremity/part of Bol'shevik Island, peninsula with cape Baranova, eastern coast of Shokal'skogo Strait, c. 1 km SE from "Prima"/"Mys Baranova" polar station, c. 400 m from the strait coast.

Topographic position: flat top of hill/terrace.

Surficial geomorphology: net of micro-depressions/ditches with plant cover and p. m. bare micro-protuberances.

Surficial geology: silt/loam + medium and coarse gravels.

Moisture status: xeric=-1 (drainage! + exposed to winds - dried by winds).

Vegetation/live cover: form net, associated with micro-depressions.

Remark: lichens have been collected mostly from microdepressions.

Site 3 (1996.7.12.1): forb+graminoid-bryophyte-lichen polygonal gravelly tundra

Location: 79°16´ N, 101°40´ E, alt. 10-20 m a.s.l.,
Severnaya Zemlya, NW extremity/part of Bol'shevik Island, peninsula with cape Baranova, eastern coast of Shokal'skogo Strait, c. 0.5 km SE from "Prima"/"Mys Baranova" polar station, c. 100 m from the strait coast.

Topographic position: slope of terrace.

Surficial geomorphology: stripes of micro-protuberances and micro-depressions oriented along the slope.

Surficial geology: medium and coarse gravels + sandy loam.

Moisture status: moist=+1 (occasionally to somewhat wet= +2; water supply from located above snow bank; persisting some pools.

Microsites:

1) Micro-protuberances: live cover - 45% : vascular plants - 5%, bryophytes - 15%, saxicolous micro-lichens - 20%, other lichens - 15%, some most common spp.: Parmelia omphalodes, Ochrolechia frigida, Cetrariella fastigiata, some other spp.: Luzula nivalis, Eritrichium villosum, Stellaria edwardsii, Papaver polare, Saxifraga cespitosa; Dactylina arctica, Cetraria islandica, Stereocaulon sp., Flavocetraria cucullata, Cladonia spp., Brodoa sp., Thamnolia spp., non-living cover - 55%: medium and coarse gravels.
2) Micro-depressions: live cover - 75% : vascular plants - 5%, bryophytes - 30%, saxicolous micro-lichens - 10%, other lichens - 30%, some most common spp. : Cetrariella delisei, Cladonia cf. macroceras, some other spp.: Luzula nivalis, Stellaria edwardsii; Parmelia omphalodes, Stereocaulon sp., Thamnolia spp., Lecidea ramulosa, non-living cover - 25%.

3) Standing pool: live cover - 90%: bryophytes - 70%, lichens (big patch of Xanthoria elegans only) - 20%, non-living cover - 10% : gravel.

Site 4 (1996.7.13.4): lichen-bryophyte-forb+graminoid knobby tussock tundra

Location: 79°16′ N, 101°40′ E, alt. c. 20 m a.s.l.,
Severnaya Zemlya, NW extremity/part of Bol'shevik Island, peninsula with cape Baranova, eastern coast of Shokal'skogo Strait, c. 1 km E-SE from "Prima"/"Mys Baranova" polar station, c. 500 m from the strait coast.

Topographic position: gently inclined slope of coastal terrace.

Surficial geomorphology: irregular weakly expressed microrelief of small knobs.

Moisture status: wet=+2.

Live cover: - 20%, vascular plants - 10%, bryophytes - 5%, lichens - 5%, some most common spp.: cushions of Deschampsia glauca, Stellaria edwardsii; Lecidea ramulosa, Stereocaulon sp., Thamnolia spp., Cladonia cf. macroceras, some add. spp.: Lecanora geophila (along small water track); Aulacomnium turgidum, non-living cover - 80% : fine gravel - 60%, clay - 20%.

Site 7 (1996.7.16.3): forb-bryophyte-lichen tundra

Location: 79°02′ N, 102°43′ E, alt. 60 m a.s.l.,
Severnaya Zemlya, N part of Bol'shevik Island, western coast of Akhmatov Bay, 11 km S of the mouth of Bazovaia River, 1 km from the bay coast.

Topographic position: gently inclined coastal terrace.

Surficial geology: gravel + sandy silt.

Surficial geomorphology: fields of gravel with stone.

Moisture status: mesic=0.

Some registrated spp.: Novosieversia glacialis, Dryas punctata, Papaver polare, Saxifraga oppositifolia, S. cespitosa, S. serpyllifolia, Potentilla hyparctica.

Microsite additional site 7 (1996.7.16.1)

Location: 79°03′ N, 102°42′ E, alt. 50 m a.s.l.,
Severnaya Zemlya, N part of Bol'shevik Island, western coast of Akhmatov Bay, 10 km S of the mouth of Bazovaia River, 1 km from the bay coast.

Topographic position: crack at a p. m. flat to gently inclined coastal terrace.

Surficial geology: gravel (+ soil).

Surficial geomorphology: microsite: surface crack/fissure with bryophytes and lichens.

Moisture status: moist=+1 (but at the moment - dry).

Live cover. - 100%.

Site 8 (1996.7.17.3): forb+graminoid-bryophyte-lichen fine-polygonal tundra

Location: 79°04′ N, 102°45′ E, alt. 5-15 m a.s.l.
Severnaya Zemlya, N part of Bol'shevik Island, western coast of Akhmatov Bay, 5 km S-SW of the mouth of Bazovaia River, 100-300 m from the bay coast.

Topographic position: slope of the first coastal terrace.

Surficial geomorphology: net of small cracks on the silt surface.

Surficial geology: silt with fine gravel.

Moisture status: mesic=0 (to moist=+1 (?) or dry).
Vegetation: dominating - lichen crusts on soil.
Live cover: 50%, some most common spp.: Lecanora epibryon, Lecidea ramulosa, some other spp.: Stellaria edwardsii, Poa sp.; Protoblastenia sp., Arthrorhaphis sp., non-living cover: 50%.

Site 9 (1996.7.18.2): lichen-bryophyte-forb+graminoid tussock tundra
Location: 79°04´ N, 102°45´ E, alt. 5-10 m a.s.l.
Severnaya Zemlya, N part of Bol'shevik Island, western coast of Akhmatov Bay, 6.5 km S-SW of the mouth of Bazovaia River, 300 m from the bay coast.
Topographic position: gently inclined coastal terrace.
Surficial geology: fine and medium gravel-50%, silt -50%.
Moisture status: moist=+1 (to mesic=0).
Vegetation: graminoid tussocks with bryophytes, lichens and algal crusts in between.
Live cover: 50% : vascular plants - 25%, bryophytes-15%, lichens-10%, some most common spp.: tussock-forming graminoids; Lecidea ramulosa, Thamnolia spp., Solorina saccata, Peltigera spp., Cladonia cf. macroceras; algal crusts, non-living cover: 50%.

Site 10 (1996.7.18.3 and 1996.7.18.1): forb+graminoid-lichen-bryophyte gravelly polygonal tundra
Location: 79°04´ N, 102°41´ E, alt. 40 m a.s.l.
Severnaya Zemlya, N part of Bol'shevik Island, western coast of Akhmatov Bay, 7 km SW of the mouth of Bazovaia River.
Topographic position: p. m. flat plain between mountains and bay coast.
Surficial geology: fine and medium gravel - 80% + silt/sand - 20%.
Moisture status: mesic=0 (to dry=-1 - in micro-protuberances, or moist - in micro-depressions).
Vegetation: mostly associated with micro-depressions, form net.
Live cover: 30-40% : vascular plants - 5-10%, bryophytes-40%, lichens-30%, some most common spp.: Novosieversia glacialis, Salix polaris, Potentilla sp., Luzula sp.; Catapyrenium sp. etc lichen crusts, Peltigera spp., non-living cover: 60-70%.
Microsites:
1) Micro-depressions: some locally abundant spp.: Peltigera spp., Sticta arctica, Lobaria linita (these three spp. form big patches), Thamnolia spp., Catapyrenium sp.; some other spp.: Psoroma hypnorum, Pannaria pezizoides.
2) Micro-protuberances: some locally abundant spp.: Carex sp.; Pseudephebe pubescens, Sphaerophorus fragilis (both on gravel).

3.1.3 Soils and Patterned Grounds on October Revolution Island
(T. Müller-Lupp, E.-M. Pfeiffer)

During the Severnaya Zemlya expedition in June/July 1996 typical soils and patterned grounds at Fjord-Lake, on October Revolution Island, were investigated. Figure 3-18 gives an overview of the Fjord Lake area and the sampling sites.

Patterned grounds were classified according to WASHBURN, 1979. Soils were described and classified by Keys to Soil Taxonomy (USDA 1994) and according to the Bodenkundliche Kartieranleitung (4. Auflage 1994) and FAO-Soil guideline, 1987. Nine patterned grounds and their soils were excavated and samples for grain size analyses, C-contents and iron extraction were taken. Temperature and thickness of active layer were measured.

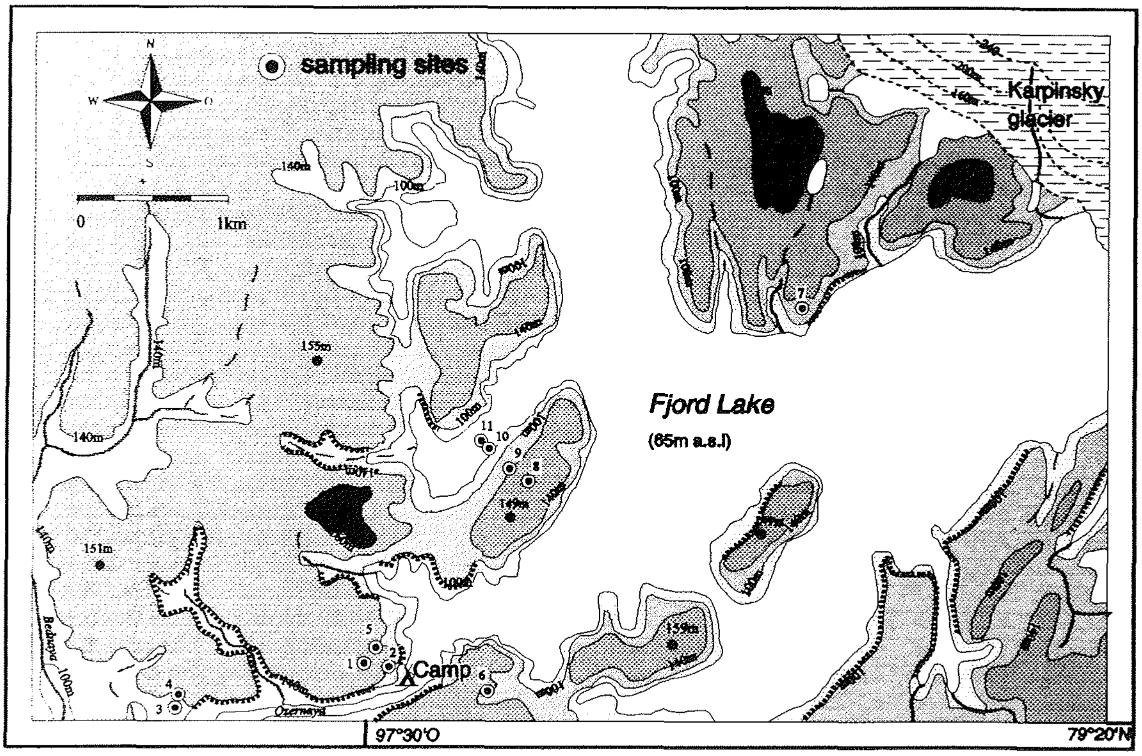


Figure 3-18: Map of Fjord Lake, October Revolution Island (for location see Fig. 3-1).

The landscape at Fjord Lake on October Revolution Island is arctic desert. The quota of vegetated area is less than 10%. Silt and silty clay are only at a few places the base for soil development. Recognizing the significant sorting process of Washburn`s classification, there are two major groups of patterned ground soil complexes at Fjord Lake: the nonsorted forms of polygons and stripes and the sorted forms of stripes.

Nonsorted polygons occur on the high plain near the camp. Their netted structure is polygonal with a diameter of 4-5 m. Their convex, nonvegetated apex is mostly divided into small sorted polygons with a diameter of 30-40 cm. The borders are up to 60 cm wide and covered by mosses and lichens. Because of the low percipitation less than 60 mm a year mainly falling in summertime the soil is saturated with water only directly after snowmelting. Nonsorted poly-

Site 3: Pergelic Cryorthent and nonsorted polygons (nets)

location:	Severnaya Zemlya, October Revolution Island, Fjord-Lake 79°20,49´ N, 97°29,82´ E
landscape:	plain, 150m a.s.l.
vegetation:	only in the fissures mosspads with *Saxifraga spec, Novosiviersia glacialis*, lichens
permafrost-table:	17-40cm
parent material:	debris of Devonian shale and sandstone
soil water status:	dry
soil-profile:	3a: C - Cw - Cf; 3b: Oi - A - Cf

Horizont		depth [cm]	description
3a	C	0-3	stone pavement with flat/angular medium and coarse gravel, net of small sorted polygons (20cm in diameter)
	Cw	3-40	silt loam with 20% medium and coarse gravel
	Cf	>24	
3b	Oi	0-3	slightly decomposed mosses
	A	3-17	silty clay loam with 20% medium gravel and occasionally stones
	Cf	>17	

remark: large polygons pentangular 4m in diameter divided in small sorted polygons wedge-shaped 6 cm deep with coarse gravels

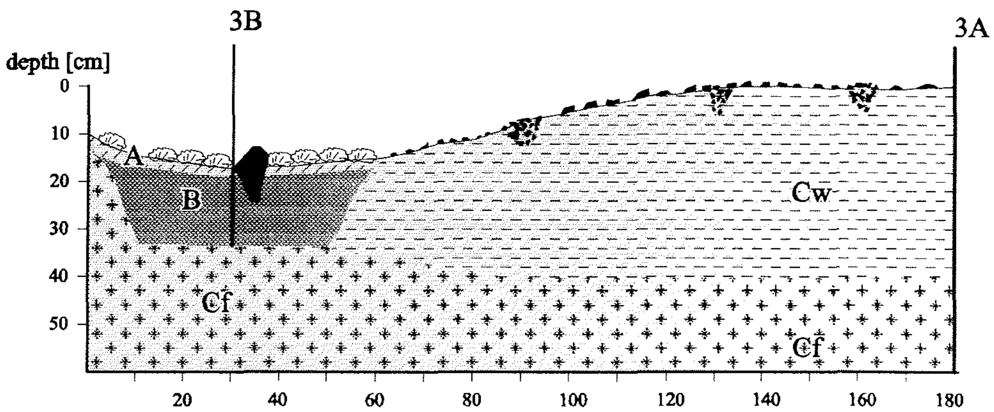


Figure: 3-19: Soil profile of site 3 on October Revolution Island.

Site 4: Oxyaquic Cryorthent and nonsorted stripes

location:	Severnaya Zemlya, October Revolution Island, Fjord-Lake 79°20,49´ N, 97°30,46´ E
landscape:	striped slope, 10°, 140m a.s.l.
vegetation:	only in the striped trough, moss pads with *Saxifraga spec, Novosiviersia glacialis*, lichens
permafrost-table:	24cm
parent material:	debris of devonian slate clay and sandstone
soil water status:	wet in the troughs
soil-profile:	4a: C - Cw - Cf, 4b: Oi - A - Cf

Horizont		depth [cm]	description
4a	C	0-3	stone pavement with flat/angular medium and coarse gravel
	Cw	3-24	silty clay loam with 15% medium and coarse gravel
	Cf	>24	frozen silty clay
4b	Oi	0-5	slightly decomposed mosses
	A	5-18	silty clay loam with 8% fine and medium gravel, free water near permafrost-table
	Cf	>18	frozen silty clay

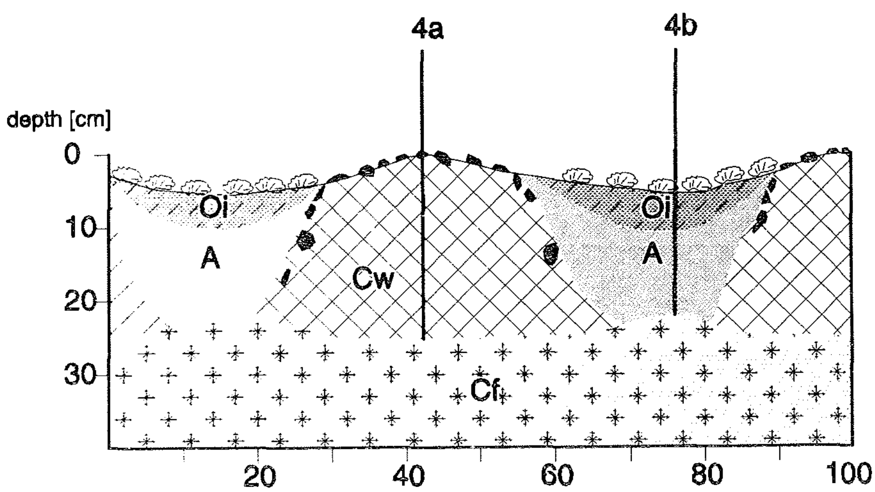


Figure 3-20: Soil profile of site 4 on October Revolution Island.

gons are less developed soils. The accumulation of organic material in O and A horizons of the borders is the predominant process. The soil of the apex is frost weathered parent material without any horizontal differentiation. The thickness of active layer depends on whether the surface is vegetated or not. The permafrost table under the vegetated borders is 14 cm deep, under the apex 40 cm. The dominant soils are Pergelic Cryorthents.

On slopes, nonsorted stripes are formed. Where vegetated stripes alternate with bare soil , no genetic horizon except the formation of an organic layer underneath the sod is detectable on the vegetated stripes themselves. The vegetated stripe is covered by mosses and lichens. Underneath, at the permafrost border free water was discovered. The soil is saturated in the summer with water coming downslope from melting snowfields. Although the active layer is saturated with water no redoximorphic features were found. One reason could be the red colour of the devonian parent material (10YR4/3) or the absence of weathered oxides for the reduction of iron shown by the aa-Dipyridyl test. The thickness of active layer in this silty clay loam is under vegetated stripes 16 cm and unter the bare stripes 21 cm. Dominant soil at this patterned ground is Oxyaquic Cryorthent.

Patterned grounds with sorted appearance were found on the peninsula north-east of the camp. The predominant patterned grounds for this area are the sorted stripes. They are similar in shape to the nonsorted stripes, but have a changing of stripes with fine material and with stones. Both stripes range from 30-50 cm wide and their long extension is mostly down the steepest available slope. Their occurence is limited to slopes with a gradient of 5° to 15°. They derive by downslope extension of the sorted polygons or nets. In dry areas the stony stripes are mostly unvegetated except of lichens, but in wet areas below longlasting snowfields mosses cover the stony stripes. Different to the sorted stripes at Lake Levinson Lessing the share of fine material is much bigger at Fjord Lake, and so there is enough storage of water for ice rich permafrost. The thickness of the active layer ranges from 25 cm under the stripes of fine material up to 35 cm under the stripes of stones and coarse gravels. The typical soils for this area are Pergelic Cryorthents or Oxyaquic Cryorthents.

On the steep slopes towards the lake there is no patterned gound and no soil. The solifluction is too strong for soil development like accumulation of organic material. Most slopes consist of debris and no permafrost is excavatable. The slopes are well drained and there is no finer material to store water and to built up ice contenting permafrost.

3.2 Lake Morphology, Hydrology, and Sedimentation

(D. Yu. Bolshiyanov, M. Melles, V. Samarkin, M. Wilmking)

3.2.1 Changeable Lake

Location and morphology. - The Changeable Lake (Ozero Izmenchivoe) is located on the southwestern October Revolution Island (79° 07′ N, 95° 07′ E; Fig. 1-3). It fills the deepest part of an oblong, structural-denudational depression, which entends below the Vavilov Ice Cap ca. 4 km to the north of Changeable Lake (Fig. 3-21).

The lake has a widely isometric form, covering an area of 10.6 km^2 (Fig. 3-22). In spite of rather shallow waters of 18.5 m maximum depth, Changeable Lake shows a complicated bathymetry. A depression of ca. 14 m water depth in the northern lake part is separated by a ridge of 7 to 11 m depth from at least three isolated depressions of ca. 16 to 18 m maximum depths in the southern lake part. With a mean water depth of 4.7 m it has a water volume of approximately $49.8 \cdot 10^6$ m^3. The lake water level is 6 m above sea level.

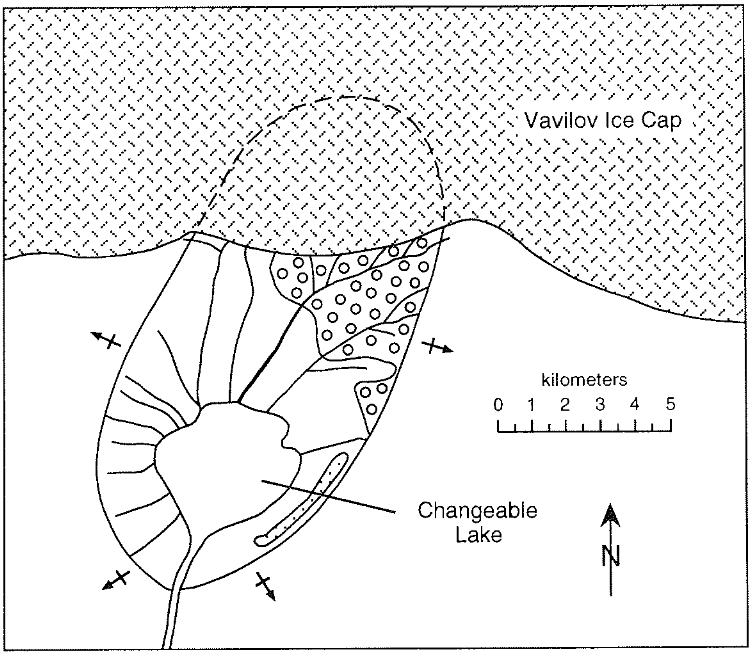


Figure 3-21: Sketch map of the Changeable Lake surroundings showing its location in an oblong depression which extends below the Vavilov Ice Cap, as well as the water inflows into the lake, the area covered by Quaternary marine sediments (open circle pattern), the location of a long-standing snow bank (dotted pattern), and the inclination direction of sedimentary rocks (crossed arrows); after Bolshiyanov & Makeev (1995).

Water flow and sedimentation. - The major inflow enters Changeable Lake by several brooks at the northern shore, supplying melt water from the ice cap (Fig. 3-21). The outflow is on the southern lake shore through a deep, narrow canyon developed in limestones. According to Bolshiyanov & Makeev (1995), melting of the ice cap and of snow fields takes place during 2.5 to 3 months between July and Sept. Water flow, sediment transport, and lake accumulation are positively correlated both with the air temperature and the wind velocity.

The solid material supplied by brooks is deposited almost completely in the lake (Bolshiyanov & Makeev, 1995). It originates mainly from bedrocks and Quaternary marine sediments located to the northeast of Changeable Lake (Fig. 3-21). Due to the concentrated fluvial sediment supply from the north, about 31,000 m^3 of sands are accumulated every year in the deltas at the

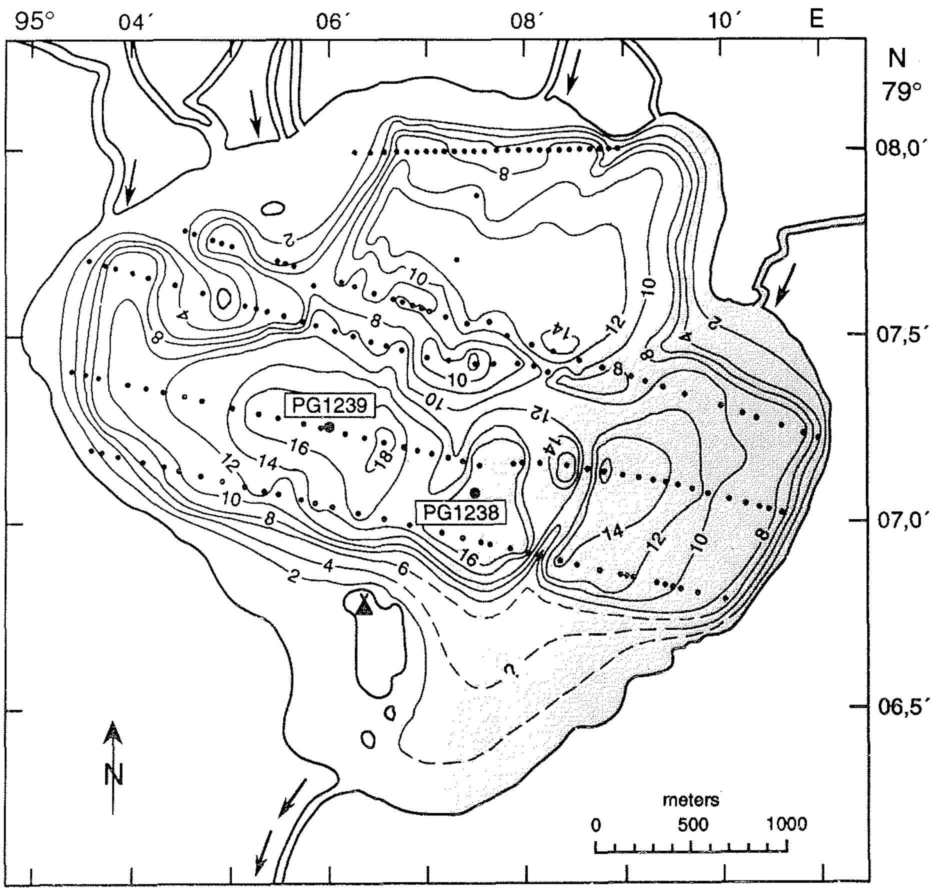


Figure 3-22: Bathymetric map of Changeable Lake (depth contours in meters), based on a large number of depth measurements (light dots); also shown are the lake sediment coring sites PG1238 and PG1239 (heavy dots), the major inflow streams at the northern shore and the outflow at the southern shore (black arrows), and the position of the field camp in summer 1996 on the island (tent symbol). For large-scale location of Changeable Lake see Fig. 1-3.

northern lake shore, leading to their advances and an annual reduction of the lake area by 0.12 km^2.

Sediment trap data obtained from the central Changeable Lake in 1978 indicate sedimentation rates of 2.0 mm for 0.58g/cm^3 density and 0.65 mm for 1.7 g/cm3 density (Bolshiyanov & Makeev, 1995). From the quantity of suspended material, determined in 1981, similar values of 2.4 mm and 0.8 mm, respectively, were calculated. This corresponds well with thicknesses of the top laminae of airdried, laminated sediments in cores from the deepest part of the lake, which varied between 0.7 and 0.8 mm. The thicknesses of annual surface layers decrease towards the southern and eastern part, and increase towards the deltas at the northern shore, where they reach up to 90 mm. Interseasonal sediment layers can be formed in summer time in case of alternating stormy and calm periods and absence of lake ice.

Lake hydrology and glaciology. - Changeable Lake usually becomes deglaciated suring the summer. According to Mordvinov (1981), the CO_2 content in the water column of this lake amounts to 7.0 - 8.4 mg/l, the pH value to 7.65, and the O_2 content to 13.1 - 14.0 mg/l. The latter data fit well with O_2 contents of 14.0 mg/l in the surface water and 12.4 mg/l near bottom, determined with a test kit (Winkler Ltd. titrimetric method) during the expedition 1996.

In addition, a hydrological depth profile was measured in June 1996 in the southwestern Changeable Lake depression using WTW (Wissenschaftlich-Technische Werkstätten GmbH, Weilheim) instruments. The results show more or less gradual increases in temperature and conductivity values towards the lake floor, starting at water depths of ca. 3 and 8 m, respectively (Fig. 3-23, Table 6-10). The pH and dissolved oxgen values, in contrast, are rapidly decreasing within the lowermost 0.7 m of the water column.

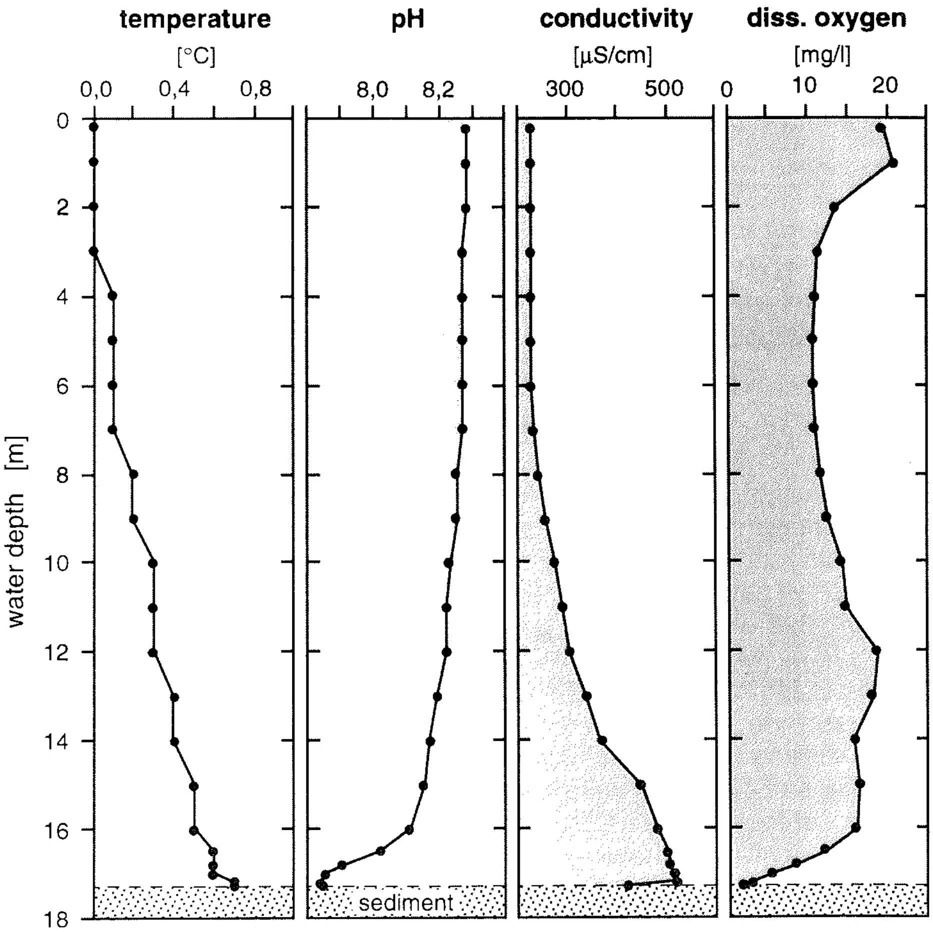


Figure 3-23: In situ measurements of hydrological parameters carried out on June 25, 1996, at sediment sampling site PG1239 in Changeable Lake (for location see Fig. 3-22); water depth is 17.3 m, temperatures are shown as the mean of all three probes.

3.5.2 Fjord Lake

Location and morphology. - The Fjord Lake (Ozero Fiordovoe) is a proglacial lake located at the western edge of the Karpinskiy Ice Cap on eastern October Revolution Island (79° 22´ N, 97° 40´ E; Fig. 1-3). It is is the largest and deepest lake on Severnaya Zemlya (Bolshiyanov & Makeev, 1995). The lake covers an area of 39.5 km^2, the length is 15.2 km, and the mean width 2.4 km (max. 9.8 km). The length of the shore line amounts to 125 km (Fig. 3-24).

Fjord Lake is located in rugget terrain. Steep slopes and cliffs occur at the shore lines of fjord-like bays and narrow peninsulas (Fig. 3-24). Maximum water depth of 97 m was found in the eastern part of the lake. From the absence of terraces and a small thickness of unconsolidated sediments, a lake formation about 350 to 500 yr BP was assumed (Bolshiyanov & Makeev, 1995).

Water flow and sedimentation. - The major water inflow comes from Karpinskiy Ice Cap during the melting period. Besides this, several brooks enter the lake at the western and southern shores (Fig. 3-24), supplying predominantly meltwater from snow fields. Water outflow is on the southwestern shore via the Ozernaya River to the south into the Kara Sea.

Lake hydrology and glaciology. - The lake level increases significantly during summer times (Mordvinov, 1981). In addition, it shows distinct daily fluctuations of up to 55 cm, correlating with air temperatures. Water temperatures are close to 0°C in winter times. At the end of July they are slightly warmer (0.3 - 0.4°C) under the ice and can reach 0.8 to 0.9°C in open water close to the shore line.

The ice cover of Fjord Lake has a mean thickness of 2.5 - 2.7 m (Mordvinov, 1981). In snow-free areas it may reach up to 3 m. In the summer, 0.8 - 1.3 m ice are usually melting. A total deglaciation occurs only in extreme warm years. In summer 1996, most parts of the lake were covered by multi-year ice. Icebergs, often strongly disintegrated, were common in those lake parts visited during the 1996 expedition (Fig. 3-24).

According to Mordvinov (1981) the O_2 contents in Fjord Lake are close to normal saturation. In summer 1974, O_2 values of 13.16 - 14.63 mg/l were measured in the surface waters and 13.25 - 14.27 mg/l close to the lake floor. Slightly higher values of 15.1 mg/l were determined in summer 1975. During the same times, the contents of free CO_2 were 4.8 - 5.5 mg/l in surface and 6.3 mg/l in bottom waters (1974), showing significantly lower values of 1.0 - 1.7 mg/l one year later (1975).

In summer 1996 measurements of O_2 contents were carried out in Fjord Lake with a test kit (Winkler Ltd. titrimetric method). With 14.1 mg/l in surface waters and 14.9 mg/l at a depth of 55 m they show strong similarity to the data determined by Mordvinov (1981) about 20 years earlier. Alkalinity measurements in

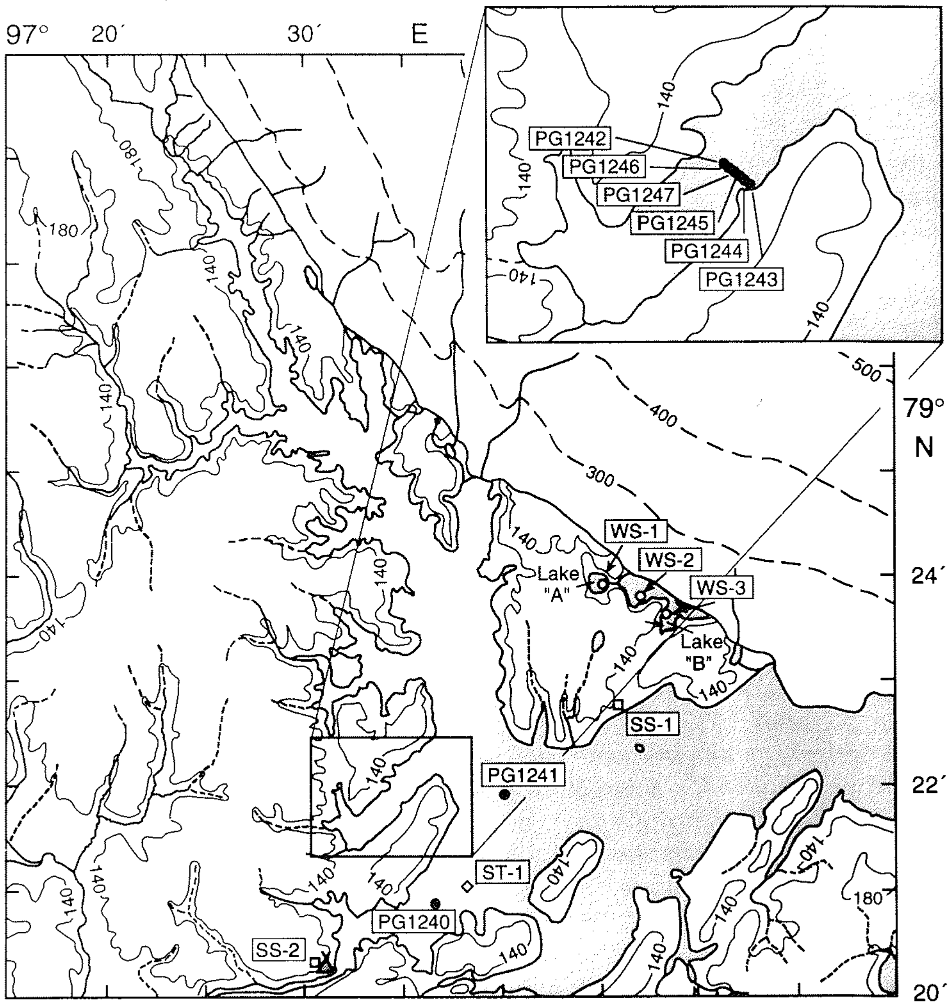


Figure 3-24: Map of Fjord Lake showing the locations of lake sediment cores (heavy dots), water samples (open circles), snow samples (open squares), sediment trap (open rhombus), and 1996 field camp at the outflow of the lake (tent symbol). For in summer 1996 on the island (tent symbol). For large-scale location of Fjord Lake see Fig. 1-3.

1996 revealed values of 0.25 - 0.30 mmol/l in the uppermost 2.5 m of the water column, and constantly about 0.4 mmol/l down to the lake floor in 55 m water depth.

Hydrological depth profiles, measured in June 1996 at two sites with WTW (Wissenschaftlich-Technische Werkstätten GmbH, Weilheim) instruments, show widely constant values of temperature (ca. 0.0°C), pH (ca. 8.0), conductivity (ca. 120 µS/cm), and dissolved oxygen (15 - 20 mg/l) below the ice cover (Tables 6-11 and 6-12).

3.3 Lake Sediment Sampling

(M. Melles, D. Yu. Bolshiyanov, V. Samarkin, M. Wilmking, T. Müller-Lupp, A. Zielke)

Lake sediments function as one of the best natural data archives for paleo-environmental reconstructions, because lakes act as sedimentary basins on the continent. The lacustrine sediments, therefore, generally represent more complete depositional sequences than other terrestrial deposits. With multi-proxi data from lake sediments, complex information concerning the environmental setting both in the catchment area and in the water column of lakes can be obtained. In addition, detailed age determinations can often be achieved by radiocarbon dating of organic matter or by counting of annual sediment layers (varves). Hence, lake sediments may supply high-resolution reconstructions of the environmental history, with good stratigraphic control.

As a consequence, lake sediment investigations play an important role within the scope of the Taymyr Project. They complement very well those paleo-environmental and paleoclimatic results derived from additional studies in the project, such as investigations of permafrost sequences and ground-ice bodies, geomorphological research, and archaeological studies (Melles et al., 1997).

Lake sediment coring in the project study area has started during a pilot expedition in summer 1993 (Melles et al., 1993, 1994a). Sediment cores of up to 10.6 m and 6.0 m lengths were recovered from the lakes Lama and Pjasino in the surroundings of the town Norilsk (Fig. 1-1). In spring 1995, the lakes Kokora, Levinson-Lessing, Taymyr, and Portnyagino on the Taymyr Peninsula were sampled (Bolshiyanov & Hubberten, 1996). The longest cores in these lakes penetrated down to 5.2 m, 22.4 m, 14.3 m, and 5.0 m, respectively. With the expedition in summer 1996, reported here, the existing lake sediment sample set from the southern and central part of the study area was extended to its northern part, on Severnaya Zemlya.

3.3.1 Sampling Technique and Attendent Investigations

The lake sediment sequences were sampled with gravity and piston corers, from a tripod with hand winches through holes in the lake ice. The gravity corer was employed for accurate sampling of the soft near-surface sediments and the overlaying bottom water. Longer sequences were recovered with the piston corer. The maximum recovery with every employment of the piston corer is limited by the tube length to 3 m. Deeper sediment horizons can also be sampled, however, because the start of the coring process during penetration of the corer can be controlled by the release of the piston, which is fixed in the tube mouth on its way through both the water column and the overlaying sediments. Hence, by coring of several overlapping depths and subsequent matching of the cores, a continuous sediment sequence of much higher length than 3 m can be obtained. A more detailed description of the sampling technique is given by Melles et al. (1994b).

Besides the lake sediment sampling, attendent investigations were carried out in order to obtain a better understanding of the present-day sediment formation in Changeable Lake and Fjord Lake. In the central lake parts, hydrological profiles from the surface water to the bottom were measured (pH, conductivity, oxygen, temperature; Tables 6-10, 6-11, 6-12, and Fig. 3-23) and sampled (Table 3-1). Water and snow samples were also taken from the catchment areas of the lakes (Tables 3-1 and 3-2).

In addition, the living planktonic diatom assemblages were caught with nets in the uppermost meters of the lake water column (Table 3-3). Finally, the sediment flux through the water column of Fjord Lake was sampled with two sediment traps, mounted in different water depths, from July 2 to 7 and July 7 to 12 (Fig. 3-24).

Table 3-1: Water samples (0.5 l) collected during the expedition Severnaya Zemlya 1996; positions after GPS (Global Positioning System); for locations of lakes "A" and "B" see Fig. 3-24.

sample no.	lake	position latitude	position longitude	water depth [m]	sample depth [m]	sample vol. [ml]	date
WS1238	Changeable	79°07.1′ N	95°07.5′ E	17.2	0.0	3 x 200	06-22-96
					2.0	3 x 200	06-22-96
					7.0	3 x 200	06-22-96
					12.0	3 x 200	06-22-96
					17.2	4 x 200	06-22-96
WS1239	Changeable	79°07.3′ N	95°06.0′ E	17.3	0.0	1 x 200	06-26-96
					6.0	1 x 200	06-26-96
					12.0	1 x 200	06-26-96
					17.0	1 x 200	06-26-96
WS1240	Fjord	79°21.2′ N	97°36.5′ E	70.8	0.0	2 x 100	07-02-96
					5.0	2 x 100	07-02-96
					15.0	2 x 100	07-02-96
					30.0	2 x 100	07-02-96
					45.0	2 x 100	07-02-96
					60.0	2 x 100	07-02-96
					70.0	2 x 100	07-02-96
					70.8	2 x 100	07-02-96
WS1241	Fjord	79°22.2′ N	97°40.4′ E	81.2	81.2	1 x 100	07-03-96
WS1242	Fjord	79°22.1′ N	97°34.4′ E	55.4	0.0	2 x 100	07-05-96
					3.0	2 x 100	07-05-96
					15.0	2 x 100	07-05-96
					30.0	2 x 100	07-05-96
					45.0	2 x 100	07-05-96
					55.0	2 x 100	07-05-96
					55.4	1 x 100	07-05-96
WS-1	Lake "A"	79°16.5′ N	97°44.5′ E	?	0.1	1 x 250	07-11-96
WS-2	Lake "B"	79°16.0′ N	97°44.5′ E	?	0.1	1 x 250	07-11-96
WS-3	Lake "B"	79°16.2′ N	97°47.0′ E	?	0.1	1 x 250	07-11-96

Table 3-2: Snow samples collected during the expedition Severnaya Zemlya 1996; positions after GPS (Global Positioning System); for locations see Figs. 3-24 and 1-3.

sample no.	area	position latitude	longitude	altitude [m]	sample vol. [ml]	date
SS-1	northern shore of Fjord Lake	79°22.4′ N	95°45.5′ E	ca. 140	100	07-11-96
SS-2	at camp Fjord Lake	79°20.3′ N	95°31.5′ E	ca. 100	30	07-11-96
SS-3	Pioner Ice Cap	79°53.3′ N	93°00.8′ E	ca. 250	100	07-13-96

Table 3-3: Diatom samples collected from lake water colums during the expedition Severnaya Zemlya 1996; positions after GPS (Global Positioning System).

sample no.	lake	location description	latitude	longitude	water depth[m]	sampled depth[m]	date
DS-1	Changeable Lake	ca. 30 m north of camp (Fig. 3-22)	79°06.1′ N	95°05.1′ E	2.7	0 - 2	06-25-96
DS-2	Changeable Lake	sedim. sampling site PG1239 (Fig. 3-22)	79°07.3′ N	95°06.0′ E	17.3	0 -10	06-25-96
DS-3	Fjord Lake	sedim. sampling site PG1240 (Fig. 3-24)	79°21.2′ N	97°36.5′ E	70.8	0 - 20	07-01-96
DS-4	Fjord Lake	sedim. sampling site PG1242 (Fig. 3-24)	79°22.1′ N	97°34.4′ E	55.4	0 - 20	07-05-96
DS-5	Fjord Lake	sedim. sampling site PG1243 (Fig. 3-24)	79°22.0′ N	97°34.8′ E	8.0	0 - 7	07-07-96
DS-6	Fjord Lake	sedim. sampling site PG1244 (Fig. 3-24)	79°22.1′ N	97°34.0′ E	12.5	0 - 12	07-07-96
DS-7	Fjord Lake	sedim. sampling site PG1245 (Fig. 3-24)	79°22.0′ N	97°34.9′ E	20.7	0 - 19	07-07-96
DS-8	Fjord Lake	sedim. sampling site PG1246 (Fig. 3-24)	79°22.1′ N	97°35.0′ E	40.5	0 - 20	07-07-96
DS-9	Fjord Lake	sedim. sampling site PG1247 (Fig. 3-24)	79°22.1′ N	97°34.8′ E	31.0	0 - 20	07-07-96

3.3.2 Changeable Lake

The Changeable Lake (Fig. 3-22) is located on the southwestern October Revolution Island (Fig. 1-3). Sediment coring was carried out at sites PG1238 in the central and PG1239 in the western depression of the southern Changeable Lake (Table 3-4). The coring in water depths of 17.2 and 17.3 m resulted in recoveries of 10.4 and 12.7 m, respectively. Due to the storage of most of the sediments in plastic liners they could be described only roughly. In both cores, a highly consolidated, poorly sorted and unstratified diamicton occurs at the base. This diamicton is interpreted as a moraine deposited during the last ice advance across the coring sites. Hence, the overlaying lacustrine sediment sequences probably comprise the complete postglacial lake history.

Table 3-4: Lake sediment cores collected during the expedition Severnaya Zemlya 1996; positions after GPS (Global Positioning System), SL = 'Schwerelot' (gravity corer), KOL = 'Kolbenlot' (piston corer).

core no. station-employ	lake	position latitude	position longitude	water depth [m]	date	gear	recovery [cm]
PG1238 - 1	Changeable	79°07.1' N	95°07.5' E	17.2	06-22-96	SL	0 - 36
- 2					06-22-96	SL	0 - 36
- 3					06-22-96	KOL	0 - 244
- 4					06-23-96	KOL	194 - 491
- 5					06-23-96	KOL	444 - 741
- 6					06-24-96	KOL	694 - 991
- 7					06-24-96	KOL	944 - 1037
PG1239 - 1	Changeable	79°07.3' N	95°06.0' E	17.3	06-26-96	SL	0 - 41
- 2					06-26-96	SL	0 - 38
- 3					06-26-96	SL	0 - 2
- 4					06-26-96	KOL	0 - 266
- 5					06-26-96	KOL	216 - 514
- 6					06-26-96	KOL	466 - 764
- 7					06-27-96	KOL	716 - 1014
- 8					06-27-96	KOL	966 - 1265
PG1240 - 1	Fjord	79°21.2' N	97°36.5' E	70.8	07-01-96	SL	0 - 14
- 2					07-01-96	SL	0 - 14
- 3					07-01-96	SL	0 - 2
- 4					07-02-96	KOL	0 - 187
PG1241 - 1	Fjord	79°22.2' N	97°40.4' E	81.2	07-03-96	SL	0 - 20
- 2					07-03-96	SL	0 - 19
- 3					07-03-96	SL	0 - 1
- 4					07-03-96	KOL	0 - 182
- 5					07-03-96	KOL	0 - 239
- 6					07-04-96	KOL	20 - 202
- 7					07-04-96	KOL	160 - 316
PG1242 - 1	Fjord	79°22.1' N	97°34.4' E	55.4	07-05-96	SL	0 - 13
- 2					07-05-96	SL	0 - 15
- 3					07-05-96	SL	0 - 1
- 4					07-06-96	KOL	10 - 178
- 5					07-07-96	SL	0 - 12
PG1243 - 1	Fjord	79°22.0' N	97°34.8' E	8.0	07-07-96	SL	0 - 1
PG1244 - 1	Fjord	79°22.1' N	97°34.0' E	12.5	07-07-96	SL	0 - 1
PG1245 - 1	Fjord	79°22.0' N	97°34.9' E	20.7	07-07-96	SL	0 - 1
PG1246 - 1	Fjord	79°22.1' N	97°35.0' E	40.5	07-07-96	SL	0 - 1
PG1247 - 1	Fjord	79°22.1' N	97°34.8' E	31.0	07-07-96	SL	0 - 1
						sum $\sum$	40.7 m

At both sites similar postglacial sediment successions were recovered. They are charcterized by a high water content, a muddy grain-size distribution, and a predominance of terrigenous sediment components throughout the sequences. Differences are most obvious in sediment colors, which change from light gray with black dots in the sediments directly overlaying the moraine, via black, to dark gray with black dots, and red in the uppermost sediment meters. These differences in sediment color are due to changes between oxic and anoxic condition in the lake or pore waters rather than to changes in the terrigenous sediment supply, because the geology in the catchment area is very uniform.

At least the uppermost 3.5 m at site PG1238 and 6.8 m at site PG1239 are built up of laminated silty clays and clayey silts. The laminae, being in average about 1 mm thick, may represent annual layers (varves). A clastic varve sedimentation in the southern part of Changeable Lake is likely, because an annual terrigenous sediment supply by melt water takes place, a depression in front of the main inflow functions as a trap for coarse-grained sediments, and a complete lake-ice coverage in winter time favours the accumulation of the fine-grained suspension load following Stokes´ Law. In deeper sediment horizons no lamination was identified by the visual core descriptions, however, it may be masked by the dark sediment colors. From the sequences recovered from Changeable Lake, therefore, we expect a varve chronology for at least the last few thousend years.

3.6.3 Fjord Lake

The Fjord Lake (Fig. 3-24) is a large proglacial lake at the western edge of the Karpinskiy Ice Cap on October Revolution Island (Fig. 1-3). Lake sediment coring was carried out in the central and southwestern parts of Fjord Lake. At three sites the piston corer was employed in order to recover long sediment cores (Table 3-4). Site PG1240 is located in the southwestern bay of Fjord Lake, about 2 km from the lake outflow, site PG1241 lies in the central part of the lake, in the junction of the main bays, and site PG1242 is the deepest site of a coring transect (PG1242-PG1247) crossing the southern slope of the first bay to the north of the outflow.

At all sites, laminated clayey silts and silty clays of red color build up the near-surface sediments. The laminae very likely represent varves. This is evidenced by the good correlation between the thicknesses of the laminated horizons and the water depths at the different coring sites (Fig. 3-25), because the model of a clastic varve sedimentation presupposes a vertical particle flux of the suspended matter during winter time. The thickness of the annual layers, therefore, should directly depend on the thickness of the overlaying water column.

Estimates of the laminae numbers indicate that the varve sedimentation started a few centuries before present. According to Bolshiyanov & Makeev (1995) the Fjord Lake was formed only about 350 -500 years ago by ice-

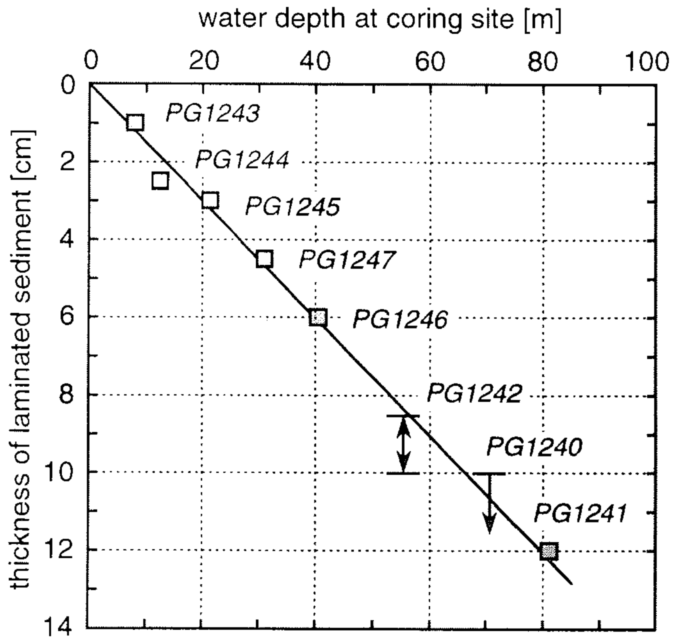


Figure 3-25: A modern clastic varve sedimentation in Fjord Lake is indicated by the good correlation between the thicknesses of the laminated near-surface sediments and the water depths at the eight coring sites in this lake (for locations see Fig. 3-24). At site PG1242 the thicknesses vary in different cores and at site PG1240 only the minimum thickness can be stated.

damming due to an advance of the Karpinsky Ice Cap. Hence, the varve sedimentation may document the major period of the lake history. As a consequence, the underlaying sediments recovered with piston cores could reflect the processes taking place during the formation of the lake or predate the lacustrine sedimentation.

At site PG1240 a graded sequence of coarse gravel at the core base to fine sand below the laminated near-surface sediments may be due to a deposition by a turbidity current event during the initial lake stage. At site PG1240 a highly consolidated, poorly sorted and unstratified diamicton at the core base may represent a moraine deposited from grounded ice masses prior to the lake formation. From the core description, which is strongly restricted by the sediment storage in plastic liners, it is not clear whether the diamicton is directly overlayn by the laminated sediments. At site PG1242 well sorted gravels at the core base are overlayn by highly consolidated clayey silts. Their high consolidation could be due to a compaction by grounded ice masses, or to their exposure by erosion of a thick overlaying sediment sequence. In both cases, the highly consolidated sediments likely represent pre-glacial deposits.

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6 APPENDIX

6.1 Lists of Samples and Stations

6.1.1 Soil and Plant Samples

Table 6-1: Soil and plant samples of the University Hamburg collected in 1996 on the Taymyr Peninsula and on the Severnaya Zemlya Archipelago.

sample no.	character of material	site	horizon
LL 96 1000	soil material	20	A1
LL 96 1001	soil material	20	A2
LL 96 1002	soil material	8	Oe
LL 96 1003	soil material	8	Bg
LL 96 1004	soil material	7	Oi
LL 96 1005	soil material	7	Oe
LL 96 1006	soil material	7	Bg
LL 96 1007	soil material	32	C1
LL 96 1008	soil material	32	A
LL 96 1009	soil material	32	A
LL 96 1010	soil material	32	C
LL 96 1011	soil material	8	Oi
LL 96 1012	soil material	8	Bg
LL 96 1013	soil material	8	Bg
LL 96 1014	soil material	7	Oi
LL 96 1015	soil material	7	Oe1
LL 96 1016	soil material	7	Oe2
LL 96 1017	soil material	7	Oe2
LL 96 2000	plant material	15	
LL 96 2001	plant material	15	
LL 96 2002	plant material	15	
LL 96 2003	plant material	15	
LL 96 2004	plant material	15	
LL 96 2005	plant material	15	
LL 96 2006	plant material	15	
LL 96 2007	plant material	15	
LL 96 2008	plant material	15	
LL 96 2009	plant material	15	
LL 96 2010	plant material	15	
LL 96 2011	plant material	15	
LL 96 2012	plant material	15	
LL 96 2013	plant material	15	
LL 96 2014	plant material	15	
LL 96 2015	plant material	15	
LL 96 2016	plant material	15	
LL 96 2017	plant material	15	
LL 96 2018	plant material	15	
LL 96 2019	plant material	15	
LL 96 2020	plant material	34	
LL 96 2021	plant material	34	
LL 96 2022	plant material	34	
LL 96 2023	plant material	34	
LL 96 2024	plant material	34	
LL 96 2025	plant material	34	
LL 96 2027	plant material	34	
LL 96 2028	plant material	34	
LL 96 2029	plant material	34	

sample no.	character of material	site	horizon
LL 96 2030	plant material	34	
LL 96 2031	plant material	34	
LL 96 2032	plant material	34	
LL 96 2033	plant material	34	
LL 96 2034	plant material	34	
LL 96 2035	plant material	34	
LL 96 2036	plant material	34	
LL 96 2037	plant material	34	
LL 96 2038	plant material	34	
LL 96 2039	plant material	34	
LL 96 2040	plant material	34	
LL 96 2041	plant material	34	
LL 96 2042	plant material	34	
LL 96 2043	pore water	15	
LL 96 2044	pore water	15	
LL 96 2045	soil material	15	A
LL 96 2046	soil material	15	A
LL 96 2047	soil material	15	A
LL 96 2048	soil material	34	A
LL 96 2049	soil material	34	A
LL 96 2050	soil material	34	A
LL 96 2051	soil material	34	A
LL 96 2052	soil material	34	A
LL 96 2053 B	soil material	34	A
LL 96 2053	plant material	32	
LL 96 2054	plant material	32	
LL 96 2055	plant material	32	
LL 96 2056	plant material	32	
LL 96 2057	plant material	32	
LL 96 2058	plant material	32	
LL 96 2059	plant material	32	
LL 96 2060	plant material	32	
LL 96 2061	plant material	32	
LL 96 2062	plant material	32	
LL 96 2063	plant material	32	
LL 96 2064	plant material	32	
LL 96 2065	plant material	32	
LL 96 2066	plant material	32	
LL 96 2067	plant material	32	
LL 96 2068	plant material	15	
LL 96 2069	plant material	15	
LL 96 2070	plant material	15	
LL 96 2071	plant material	15	
LL 96 2073	plant material	15	
LL 96 2074	plant material	15	
LL 96 2075	plant material	15	
LL 96 2076	plant material	15	

continuation next page

Table 6-1: continuation

sample no.	character of material	site	horizon
LL 96 2078	plant material	15	
LL 96 2079	plant material	15	
LL 96 2080	plant material	15	
LL 96 2081	plant material	15	
LL 96 2083	plant material	15	
LL 96 2084	plant material	15	
LL 96 2085	plant material	15	
LL 96 2086	plant material	15	
LL 96 2088	plant material	15	
LL 96 2089	plant material	15	
LL 96 2090	plant material	15	
LL 96 2091	plant material	15	
LL 96 2092	plant material	15	
LL 96 2094	plant material	15	
LL 96 2095	plant material	32	
LL 96 2096	plant material	32	
LL 96 2097	plant material	32	
LL 96 2098	plant material	32	
LL 96 2099	plant material	32	
LL 96 2100	plant material	32	
LL 96 2101	plant material	32	
LL 96 2102	plant material	32	
LL 96 2103	plant material	32	
LL 96 2104	plant material	32	
LL 96 2105	plant material	15	
LL 96 2106	plant material	15	
LL 96 2107	plant material	15	
LL 96 2108	plant material	S3	
LL 96 2109	plant material	S3	
LL 96 2110	plant material	S3	
LL 96 2111	plant material	S3	
LL 96 2112	plant material	S3	
LL 96 2113	plant material	32	
LL 96 2114	plant material	32	
LL 96 2115	plant material	32	
LL 96 2116	plant material	S3	
LL 96 2117	plant material	S3	
LL 96 2118	plant material	S3	
LL 96 2119	plant material	S3	
LL 96 2120	plant material	S3	
LL 96 2121	plant material	S3	
LL 96 2122	plant material	S3	
LL 96 2123	plant material	S3	
LL 96 2124	plant material	S3	
LL 96 2125	plant material	S3	
LL 96 2126	plant material	S2	
LL 96 2127	plant material	S2	
LL 96 2128	plant material	S2	
LL 96 2129	plant material	S2	
LL 96 2130	plant material	S2	
LL 96 2131	plant material	34	
LL 96 2132	plant material	34	
LL 96 2133	plant material	34	
LL 96 2134	plant material	34	
LL 96 2135	plant material	34	
LL 96 2136	plant material	34	

sample no.	character of material	site	horizon
LL 96 2137	plant material	S2	
LL 96 2138	plant material	S2	
LL 96 2139	plant material	S2	
LL 96 2140	plant material	S2	
LL 96 2141	plant material	S2	
LL 96 2142	plant material	S2	
LL 96 2143	plant material	7	
LL 96 2144	plant material	7	
LL 96 2145	plant material	7	
LL 96 2146	plant material	34	
LL 96 2147	plant material	34	
LL 96 2148	plant material	34	
LL 96 2149	plant material	34	
LL 96 2150	plant material	34	
LL 96 2507	root material	15	
LL 96 2508	root material	15	
LL 96 2509	root material	15	
LL 96 2510	root material	15	
LL 96 2511	root material	15	
LL 96 2512	root material	15	
LL 96 2513	root material	15	
LL 96 2514	root material	15	
LL 96 2515	root material	15	
LL 96 2516	root material	15	
LL 96 2517	root material	15	
LL 96 2518	root material	15	
LL 96 2519	root material	15	
LL 96 2520	root material	15	
LL 96 2521	root material	15	
LL 96 2522	root material	34	
LL 96 2523	root material	34	
LL 96 2524	root material	34	
LL 96 2525	root material	34	
LL 96 2526	root material	34	
LL 96 2527	root material	34	
LL 96 2528	root material	34	
LL 96 2529	root material	34	
LL 96 2530	root material	34	
LL 96 2531	root material	34	
LL 96 2532	root material	34	
LL 96 2533	root material	34	
LL 96 2534	root material	34	
LL 96 2535	root material	34	
LL 96 2536	root material	34	
LL 96 2537	root material	34	
LL 96 2538	root material	34	
LL 96 2539	root material	34	
LL 96 2540	root material	34	
LL 96 2541	root material	34	
LL 96 2542	root material	34	
LL 96 2543	root material	34	
LL 96 2544	root material	34	
LL 96 2545	root material	34	
LL 96 2546	root material	34	
LL 96 2547	root material	34	
LL 96 2548	root material	34	

continuation next page

Table 6-1: continuation

sample no.	character of material	site	horizon
LL 96 2549	root material	34	
LL 96 2550	root material	34	
LL 96 2551	root material	15	
LL 96 2552	root material	15	
LL 96 2553	root material	15	
LL 96 2554	root material	15	
LL 96 2555	root material	15	
LL 96 2556	root material	15	
LL 96 2557	root material	15	
LL 96 2558	root material	15	
LL 96 2559	root material	15	
LL 96 2560	root material	15	
LL 96 2561	root material	15	
LL 96 2562	root material	15	
LL 96 2563	root material	15	
LL 96 2564	root material	15	
LL 96 2565	root material	15	
LL 96 2566	root material	34	
LL 96 2567	root material	34	
LL 96 2568	root material	34	
LL 96 2569	root material	34	
LL 96 2570	root material	34	
LL 96 2571	root material	34	
LL 96 2572	root material	34	
LL 96 2573	root material	34	
LL 96 2574	root material	34	
LL 96 2575	root material	34	
LL 96 2576	root material	34	
LL 96 2577	root material	34	
LL 96 2578	root material	34	
LL 96 2579	root material	34	
LL 96 2580	root material	34	
LL 96 2581	root material	34	
LL 96 2582	root material	34	
LL 96 2583	root material	34	
LL 96 2584	root material	34	
LL 96 2585	root material	34	
LL 96 2586	root material	34	
LL 96 2587	root material	34	
LL 96 2588	root material	34	
LL 96 2589	root material	34	
LL 96 2590	root material	34	
LL 96 2591	root material	34	
LL 96 2592	root material	34	
LL 96 2593	root material	34	
LL 96 2594	root material	34	
LL 96 2595	root material	34	

sample no.	character of material	site	horizon
LL 96 3001	soil material	Lele1a	A
LL 96 3002	soil material	Lele1b	Bg
LL 96 3003	soil material	Lele1c	Ab
LL 96 3004	soil material	Lele2a	Cw1
LL 96 3005	soil material	Lele2c	A
LL 96 3006	soil material	Lele2a	Cw2
LL 96 3007	soil material	Lele4a	AC
LL 96 3008	soil material	Lele5a	A
LL 96 3009	soil material	Lele5a	Cw
LL 96 3010	soil material	Lele6a	A
LL 96 3011	soil material	Lele6b	A
LL 96 3012	soil material	Lele7a	AC1
LL 96 3013	soil material	Lele7a	AC2
LL 96 3014	soil material	Lele7a	Ab
LL 96 3015	soil material	Lele7a	Cw
LL 96 3016	soil material	Lele7b	A
LL 96 3017	soil material	Lele7b	Cw
LL 96 3018	soil material	Lele9a	Bg
LL 96 3019	soil material	Lele9b	Ab
LL 96 3020	soil material	Lele9b	AC
LL 96 3021	soil material	Lele10b	Cf
LL 96 3022	soil material	Lele10a	AC1
LL 96 3023	soil material	Lele10a	AC2
LL 96 3024	soil material	Lele11a	Cw
LL 96 3025	soil material	Lele11b	Cw
LL 96 3026	soil material	Lele9a	Cf
LL 96 3027	soil material	Lele9c	Bg
LL 96 3028	soil material	Lele13a	Cw
LL 96 3029	soil material	Lele13b	AC
LL 96 3030	soil material	Lele14a	AC
LL 96 3031	soil material	Lele14a	Cw
LL 96 3032	soil material	Lele14b	A
LL 96 3033	soil material	Lele14b	Cw
LL 96 3034	soil material	Lele15a	ACw
LL 96 3035	soil material	Lele15a	Ab
LL 96 3036	soil material	Lele15a	Cg
LL 96 3037	soil material	Lele15b	Oi(e)
LL 96 3038	soil material	Lele15b	Cg
LL 96 3039	soil material	Lele15b	Cg
SeZe 96 4001	soil material	Seze1	Cw1
SeZe 96 4002	soil material	Seze1	Cw2
SeZe 96 4003	soil material	Seze1	Cw3
SeZe 96 4004	soil material	Seze3b	A
SeZe 96 4005	soil material	Seze3b	Cw1
SeZe 96 4006	soil material	Seze3a	Cw
SeZe 96 4007	soil material	Seze4a	Cw
SeZe 96 4008	soil material	Seze4b	A
SeZe 96 4009	soil material	Seze4b	AC

Table 6-2: Air-dried soil samples of the University Kiel collected in 1996 on the Taymyr Peninsula for pedological analyses (soil microbial habitat).

sample (airdried)	date	profile	horizon/depth	pH [CaCl2]
LL 001	22.07.1996	1/96	Oi	6,1
LL 002	22.07.1996	1/96	Bg	6,0
LL 003	23.07.1996	2/96	Oi	5,2
LL 004	23.07.1996	2/96	Oe1	-
LL 005	23.07.1996	2/96	Oe2	5,5
LL 006	28.07.1996	3/96	Oi	6,5
LL 007	28.07.1996	3/96	Oe	6,7
LL 008	28.07.1996	3/96	Bg	6,3
LL 009	28.07.1996	4/96	Oi	7,0
LL 010	28.07.1996	4/96	Oe	7,0
LL 011	28.07.1996	4/96	Bg	6,5
LL 012	31.07.1996	5/96	Oi	6,6
LL 013	31.07.1996	5/96	Oe1	5,4
LL 014	31.07.1996	5/96	Oe2	5,8
LL 015	31.07.1996	5/96	Bg	5,8
LL 016	31.07.1996	5/96	II Oe	5,6
LL 017	03.08.1996	6/96	Oa1	5,9
LL 018	03.08.1996	6/96	Oa2	6,5
LL 019	03.08.1996	6/96	Oa3	6,4
LL 020	03.08.1996	6/96	Bg	6,3
LL 021	03.08.1996	6/96	II Oe	6,1
LL 022	03.08.1996	7/96	Oe1	6,2
LL 023	03.08.1996	7/96	Oe2	6,1
LL 024	07.08.1996	9.1/96	surface stones	-
LL 025	07.08.1996	9.1/96	AC1 (0-0,5)	-
LL 026	07.08.1996	9.1/96	AC1 (0-4)	7,2
LL 027	07.08.1996	9.1/96	C2	7,4
LL 028	07.08.1996	9.2/96	Oi	7,5
LL 029	07.08.1996	9.2/96	Oie	7,6
LL 030	07.08.1996	9.2/96	B/C	7,6
LL 031	09.08.1996	10.1/96	A	6,2
LL 032	09.08.1996	10.1/96	C	6,6
LL 033	09.08.1996	10.2/96	Oi (0-2)	6,0
LL 034	09.08.1996	10.2/96	Oi (2-3)	6,4
LL 035	09.08.1996	10.2/96	A	6,2
LL 036	09.08.1996	10.2/96	C1	6,4
LL 037	10.08.1996	8.1/96	C1(0-2)	5,5
LL 038	10.08.1996	8.1/96	C1 (2-4)	-
LL 039	10.08.1996	8.1/96	C2	5,3
LL 040	10.08.1996	8.2/96	Oi	4,6
LL 041	10.08.1996	8.2/96	A	5,7
LL 042	10.08.1996	8.2/96	Bg (5-9)	5,3
LL 043	10.08.1996	8.2/96	Bg (>9)	-
LL 044	10.08.1996	11.1/96	A	6,2
LL 045	10.08.1996	11.1/96	BG	5,4
LL 046	10.08.1996	11.2/96	Oi	6,2
LL 047	10.08.1996	11.2/96	Oe	5,7
LL 048	10.08.1996	11.2/96	Bg	5,4
LL 049	12.08.1996	3/96	frost boil (0-4)	-

Table 6-3: Fresh soil samples of the University Kiel collected in 1996 on the Taymyr Peninsula for soil microbiological analyses.

sample (fresh)	profile	horizon/depth	H2O [Gew. %]	pH [CaCl2]
LL 201	1/96	Oi (0-5)	64,4	6,1
LL 202	1/96	Oi (5-10)	59,3	-
LL 203	1/96	Bg	44,1	6,0
LL 204	2/96	Oi	85,1	5,2
LL 205	2/96	Oe1	74,9	-
LL 206	2/96	Oe2	65,4	5,5
LL 207	3/96	Oi	64,1	6,5
LL 208	3/96	Oe	72,8	6,7
LL 209	3/96	Bg	50,2	6,3
LL 210	4/96	Oi	76,2	7,0
LL 211	4/96	Oe	79,8	7,0
LL 212	4/96	Bg	52,3	6,5
LL 213	5/96	Oi	78,9	6,6
LL 214	5/96	Oe1	76,5	5,4
LL 215	5/96	Oe2	63,6	5,8
LL 216	5/96	Bg	39,0	5,8
LL 217	5/96	II Oe	55,1	5,6
LL 218	6/96	Oa1	72,3	5,9
LL 219	6/96	Oa2	63,2	6,5
LL 220	6/96	Oa3	50,3	6,4
LL 221	6/96	Bg	29,0	6,3
LL 222	6/96	II Oe	54,6	6,1
LL 223	7/96	Oe1	81,0	6,2
LL 224	7/96	Oe2	70,8	6,1
LL 225	9.1/96	AC1 (0-0,5)	-	7,0
LL 226	9.1/96	AC1 (0-4)	17,0	7,2
LL 227	9.1/96	C2	13,0	7,4
LL 228	9.2/96	Oi	76,7	7,5
LL 229	9.2/96	Oie (2-3)	72,2	7,6
LL 230	9.2/96	Oie (3-4)	-	-
LL 231	9.2/96	B/C	26,3	7,6
LL 232	10.1/96	A (0-0,5)	-	-
LL 233	10.1/96	A (0-11)	13,6	6,2
LL 234	10.1/96	C	15,4	6,6
LL 235	10.2/96	Oi (0-2)	57,4	6,0
LL 236	10.2/96	Oi (2-3)	59,7	6,4
LL 237	10.2/96	A	46,7	6,2
LL 238	10.2/96	C	44,3	6,4
LL 239	8.1/96	C1(0-0,5)	-	-
LL 240	8.1/96	C1(0-2)	23,9	5,5
LL 241	8.1/96	C1 (2-4)	-	-
LL 242	8.1/96	C2	29,3	5,3
LL 243	8.2/96	Oi	78,3	4,6
LL 244	8.2/96	A	48,2	5,7
LL 245	8.2/96	Bg (5-9)	28,3	5,3
LL 246	8.2/96	Bg (>9)	-	-
LL 247	11.1/96	A	46,5	6,2
LL 248	11.1/96	Bg	25,2	5,4
LL 249	11.2/96	Oi	80,8	6,2
LL 250	11.2/96	Oe	80,48	5,7
LL 251	11.2/96	Bg	25,0	5,4
LL 252	3/96	frost boil (0-4)		

Table 6-4: Core samples for soil thin sections of the University Kiel collected in 1996 on the Taymyr Peninsula.

core sample	core no.	date	profile	horizon
1	10049	22.07.1996	1/96	Oi
2	10152	22.07.1996	1/96	Oi
3	k58	12.08.1996	3/96	Oi
4	k416	12.08.1996	3/96	Oi
5	k956	12.08.1996	3/96	Oi
6	k519	12.08.1996	3/96	Oi
7	101	12.08.1996	3/96	Oi
8	10050	28.07.1996	4/96	Oi
9	10162	28.07.1996	4/96	Oi
10	10160	28.07.1996	4/96	Oi
11	10157	28.07.1996	4/96	Oi
12	10161	28.07.1996	4/96	Oi
13	10121	07.08.1996	9.1/96	AC (apex)
14	10122	07.08.1996	9.1/96	AC (apex)
15	10123	07.08.1996	9.1/96	AC (apex)
16	10124	07.08.1996	9.1/96	AC (apex)
17	10125	07.08.1996	9.1/96	AC (apex)
18	10126	07.08.1996	9.2/96	Oi
19	10127	07.08.1996	9.2/96	Oi
20	10128	07.08.1996	9.2/96	Oi
21	10129	07.08.1996	9.2/96	Oi
22	10130	07.08.1996	9.2/96	Oi
23	10166	09.08.1996	10.2/96	Oi/A
24	10165	09.08.1996	10.2/96	Oi/A
25	10164	09.08.1996	10.2/96	Oi/A
26	10135	09.08.1996	10.2/96	Oi/A
27	10167	09.08.1996	10.2/96	Oi/A
28	10163	10.08.1996	8.1/96	C1(mud pit)
29	10131	10.08.1996	8.1/96	C1(mud pit)
30	10136	10.08.1996	8.1/96	C1(mud pit)
31	10134	10.08.1996	8.1/96	C1(mud pit)
32	10133	10.08.1996	8.1/96	C1(mud pit)
33	k501	10.08.1996	8.2/96	A
34	k327	10.08.1996	8.2/96	A
35	179	10.08.1996	8.2/96	A
36	k533	10.08.1996	8.2/96	A
37	k490	10.08.1996	8.2/96	A
38	10140	12.08.1996	3/96	mud pit
39	10139	12.08.1996	3/96	mud pit
40	10138	12.08.1996	3/96	mud pit
41	10143	12.08.1996	3/96	mud pit
42	10144	12.08.1996	3/96	mud pit
43	10137	12.08.1996	5/96	Oi/Oe1
44	10141	12.08.1996	5/96	Oi/Oe1
45	10142	12.08.1996	5/96	Oi/Oe1
46	10132	12.08.1996	5/96	Oi/Oe1
47	k51	12.08.1996	5/96	Oi/Oe1
48	95	12.08.1996	6/96	Oa1/Oa2
49	524	12.08.1996	6/96	Oa1/Oa2
50	T259	12.08.1996	6/96	Oa1/Oa2
51	k542	12.08.1996	6/96	Oa1/Oa2
52	T230	12.08.1996	6/96	Oa1/Oa2

6.1.2 Permafrost Samples

Table 6-5: Ground samples from Cape Sabler, Taymyr Peninsula, collected for the University Moscow during the expedition in 1996 (in column 'sample character': * = with plant remains, ** = with wood remains).

sample no.	site no.	depth [m]	sample character	type of analyses						
				pollen	diatoms	grain sizes	mineralog.	geochemical C,N,S	Corg	δ13C
SAO-1/1	SAO-1	0,1	turf	x	x		x	x	x	x
SAO-1/2	SAO-1	0,2	silt with	x	x	x	x	x	x	x
SAO-1/3	SAO-1	0,3	plant re-	x	x	x	x	x	x	x
SAO-1/4	SAO-1	0,4	mains and	x	x	x	x	x	x	x
SAO-1/5	SAO-1	0,5	ferrugini-	x	x	x	x	x	x	x
SAO-1/6	SAO-1	0,6	zation	x	x	x	x	x	x	x
SAO-1/7	SAO-1	0,7	marks	x	x	x	x	x	x	x
SAO-1/8	SAO-1	0,8		x	x		x	x	x	x
SAO-1/9	SAO-1	0,9		x	x		x	x	x	x
SAO-1/10	SAO-1	1	peat with	x	x		x	x	x	x
SAO-1/11	SAO-1	1,1	silt	x	x		x	x	x	x
SAO-1/12	SAO-1	1,2	particles	x	x		x	x	x	x
SAO-1/13	SAO-1	1,3	and silt	x	x		x	x	x	x
SAO-1/14	SAO-1	1,4	interbeds	x	x		x	x	x	x
SAO-1/15	SAO-1	1,5		x	x		x	x	x	x
SAO-1/16	SAO-1	1,6		x	x		x	x	x	x
SAO-1/17	SAO-1	1,7		x	x	x	x	x	x	x
SAO-1/18	SAO-1	1,8	silt with	x	x	x	x	x	x	x
SAO-1/19	SAO-1	1,9	plant	x	x	x	x	x	x	x
SAO-1/20	SAO-1	2	remains	x	x	x	x	x	x	x
SAO-1/21	SAO-1	2,1	and nest	x	x	x	x	x	x	x
SAO-1/22	SAO-1	2,2	and lens	x	x	x	x	x	x	x
SAO-1/23	SAO-1	2,4	of peat	x	x	x	x	x	x	x
SAO-1/24	SAO-1	2,5		x	x	x	x	x	x	x
SAO-1/25	SAO-1	2,6		x	x	x	x	x	x	x
SAO-1/26	SAO-1	2,7	peat with	x	x		x	x	x	x
SAO-1/27	SAO-1	2,8	plant	x	x		x	x	x	x
SAO-1/28	SAO-1	2,9	remains	x	x		x	x	x	x
SAO-1/29	SAO-1	3		x	x	x	x	x	x	x
SAO-1/30	SAO-1	3,5		x	x	x	x	x	x	x
SAO-1/31	SAO-1	3,7	silt	x	x	x	x	x	x	x
SAO-1/32	SAO-1	3,9	with	x	x	x	x	x	x	x
SAO-1/33	SAO-1	4,1	plant	x	x	x	x	x	x	x
SAO-1/34	SAO-1	4,3	remains	x	x	x	x	x	x	x
SAO-1/35	SAO-1	4,5		x	x	x	x	x	x	x
SAO-1/36	SAO-1	4,7		x	x	x	x	x	x	x
SAO-1/37	SAO-1	5		x	x	x	x	x	x	x
SAO-1/38	SAO-1	5,2		x	x	x	x	x	x	x
SAO-1/39	SAO-1	5,4		x	x		x	x	x	x
SAO-1/40	SAO-1	5,5	silt,	x	x		x	x	x	x
SAO-1/41	SAO-1	5,7	silt peat	x	x		x	x	x	x
SAO-1/42	SAO-1	5,9		x	x		x	x	x	x
SAO-1/43	SAO-1	6		x	x		x	x	x	x
SAO-1/44	SAO-1	6,1		x	x		x	x	x	x
SAO-1/45	SAO-1	6,2		x	x		x	x	x	x
SAO-1/46	SAO-1	6,4		x	x	x	x	x	x	x
SAO-1/47	SAO-1	6,6		x	x	x	x	x	x	x
SAO-1/48	SAO-1	6,8		x	x	x	x	x	x	x
SAO-1/49	SAO-1	7		x	x	x	x	x	x	x

continuation next page

Table 6-5: continuation

sample no.	site no.	depth [m]	sample character	pol-len	dia-toms	grain sizes	mine-ralog.	geochemical C,N,S	Corg	δ 13C
SAO-1/50	SAO-1	7,2		x	x	x	x	x	x	x
SAO-1/51	SAO-1	7,4		x	x	x	x	x	x	x
SAO-1/52	SAO-1	7,6		x	x	x	x	x	x	x
SAO-1/53	SAO-1	7,8		x	x	x	x	x	x	x
SAO-1/54	SAO-1	8		x	x	x	x	x	x	x
SAO-1/55	SAO-1	8,2		x	x	x	x	x	x	x
SAO-1/56	SAO-1	8,4		x	x	x	x	x	x	x
SAO-1/57	SAO-1	8,6		x	x	x	x	x	x	x
SAO-1/58	SAO-1	8,8		x	x	x	x	x	x	x
SAO-1/59	SAO-1	9		x	x	x	x	x	x	x
SAO-1/60	SAO-1	9,2		x	x	x	x	x	x	x
SAO-1/61	SAO-1	9,4		x	x	x	x	x	x	x
SAO-1/62	SAO-1	9,6		x	x	x	x	x	x	x
SAO-1/63	SAO-1	9,8		x	x	x	x	x	x	x
SAO-1/64	SAO-1	10		x	x	x	x	x	x	x
SAO-1/65	SAO-1	11,4		x	x	x	x	x	x	x
SAO-1/66	SAO-1	11,6		x	x	x	x	x	x	x
SAO-1/67	SAO-1	11,8	stratified	x	x	x	x	x	x	x
SAO-1/68	SAO-1	12	silt	x	x	x	x	x	x	x
SAO-1/69	SAO-1	12,2	with	x	x	x	x	x	x	x
SAO-1/70	SAO-1	12,4	plant	x	x	x	x	x	x	x
SAO-1/71	SAO-1	12,6	remains	x	x	x	x	x	x	x
SAO-1/72	SAO-1	12,8	and	x	x	x	x	x	x	x
SAO-1/73	SAO-1	13	detritus	x	x	x	x	x	x	x
SAO-1/74	SAO-1	13,2		x	x	x	x	x	x	x
SAO-1/75	SAO-1	13,4		x	x	x	x	x	x	x
SAO-1/76	SAO-1	13,6		x	x	x	x	x	x	x
SAO-1/77	SAO-1	13,8		x	x	x	x	x	x	x
SAO-1/78	SAO-1	14,2		x	x	x	x	x	x	x
SAO-1/79	SAO-1	14,4		x	x	x	x	x	x	x
SAO-1/80	SAO-1	14,6		x	x	x	x	x	x	x
SAO-1/81	SAO-1	15,6		x	x	x	x	x	x	x
SAO-1/82	SAO-1	15,9		x	x	x	x	x	x	x
SAO-1/83	SAO-1	16,2		x	x	x	x	x	x	x
SAO-1/84	SAO-1	16,5		x	x	x	x	x	x	x
SAO-1/85	SAO-1	16,8		x	x	x	x	x	x	x
SAO-1/86	SAO-1	17,1		x	x	x	x	x	x	x
SAO-1/87	SAO-1	17,4		x	x	x	x	x	x	x
SAO-1/88	SAO-1	17,7		x	x	x	x	x	x	x
SAO-1/89	SAO-1	21		x	x	x	x	x	x	x
SAO-1/90	SAO-1	21,5	peat *	x	x		x	x	x	x
SAO-1/91	SAO-1	21,9		x	x	x	x	x	x	x
SAO-1/92	SAO-1	22		x	x	x	x	x	x	x
SAO-1/93	SAO-1	22,2		x	x	x	x	x	x	x
SAO-1/94	SAO-1	22,3	silt	x	x	x	x	x	x	x
SAO-1/95	SAO-1	22,5	with	x	x	x	x	x	x	x
SAO-1/96	SAO-1	22,6	plant	x	x	x	x	x	x	x
SAO-1/97	SAO-1	22,8	and	x	x	x	x	x	x	x
SAO-1/98	SAO-1	23	wood	x	x	x	x	x	x	x
SAO-1/99	SAO-1	23,1	remains	x	x	x	x	x	x	x
SAO-1/100	SAO-1	23,3		x	x	x	x	x	x	x
SAO-1/101	SAO-1	23,4		x	x	x	x	x	x	x
SAO-1/102	SAO-1	23,6		x	x	x	x	x	x	x
SAO-1/103	SAO-1	23,7		x	x	x	x	x	x	x

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Table 6-5: continuation

sample no.	site no.	depth [m]	sample character	type of analyses						
				pol-len	dia-toms	grain sizes	mine-ralog.	geochemical C,N,S	C_{org}	δ13C
SAO-1/104	SAO-1	24	interbed-	x	x	x	x	x	x	x
SAO-1/105	SAO-1	25	ding of	x	x	x	x	x	x	x
SAO-1/106	SAO-1	25,2	loam, silt,	x	x	x	x	x	x	x
SAO-1/107	SAO-1	25,4	and sand	x	x		x	x	x	x
SAO-3/1	SAO-3	0,1	grey and	x	x	x	x	x	x	x
SAO-3/2	SAO-3	0,2	yellow	x	x	x	x	x	x	x
SAO-3/3	SAO-3	0,3	fine sand	x	x	x	x	x	x	x
SAO-3/4	SAO-3	0,4	with detri-	x	x	x	x	x	x	x
SAO-3/5	SAO-3	0,5	tus and	x	x	x	x	x	x	x
SAO-3/6	SAO-3	0,6	plant	x	x	x	x	x	x	x
SAO-3/7	SAO-3	0,7	remains,	x	x	x	x	x	x	x
SAO-3/8	SAO-3	0,8	and lens	x	x	x	x	x	x	x
SAO-3/9	SAO-3	0,9	of peat	x	x	x	x	x	x	x
SAO-3/10	SAO-3	1	and moss	x	x	x	x	x	x	x
SAO-3/11	SAO-3	1,1	inter--	x	x	x	x	x	x	x
SAO-3/12	SAO-3	1,3	bedding	x	x	x	x	x	x	x
SAO-3/13	SAO-3	1,5	of fine-	x	x	x	x	x	x	x
SAO-3/14	SAO-3	1,7	grained	x	x	x	x	x	x	x
SAO-3/15	SAO-3	1,9	sand	x	x	x	x	x	x	x
SAO-3/16	SAO-3	2,1	and silt	x	x	x	x	x	x	x
SAO-3/17	SAO-3	2,3	with	x	x	x	x	x	x	x
SAO-3/18	SAO-3	2,5	includ-	x	x	x	x	x	x	x
SAO-3/19	SAO-3	2,7	ings of	x	x	x	x	x	x	x
SAO-3/20	SAO-3	2,9	plant	x	x	x	x	x	x	x
SAO-3/21	SAO-3	3,1	remains	x	x		x	x	x	x
SAO-4/1	SAO-4	0,1	decom-	x	x	x	x	x	x	x
SAO-4/2	SAO-4	0,3	posed	x	x	x	x	x	x	x
SAO-4/3	SAO-4	0,5	peat	x	x	x	x	x	x	x
SAO-4/4	SAO-4	0,7	silt	x	x		x	x	x	x
SAO-4/5	SAO-4	0,9	peat	x	x		x	x	x	x
SAO-4/6	SAO-4	1,1	silt	x	x	x	x	x	x	x
SAO-4/7	SAO-4	1,3	with	x	x	x	x	x	x	x
SAO-4/8	SAO-4	1,5	lens of	x	x	x	x	x	x	x
SAO-4/9	SAO-4	1,7	peat	x	x	x	x	x	x	x
SAO-4/10	SAO-4	1,9	inter-	x	x	x	x	x	x	x
SAO-4/11	SAO-4	2,1	bedding	x	x	x	x	x	x	x
SAO-4/12	SAO-4	2,3	of silt,	x	x	x	x	x	x	x
SAO-4/13	SAO-4	2,5	sand,	x	x	x	x	x	x	x
SAO-4/14	SAO-4	2,7	and peat	x	x		x	x	x	x
SAB-1/1	SAB-1	0,3	peat	x	x	x	x	x	x	x
SAB-1/2	SAB-1	0,5	silt	x	x	x	x	x	x	x
SAB-1/3	SAB-1	0,7	peat *	x	x	x	x	x	x	x
SAB-1/4	SAB-1	0,9	silt **	x	x	x	x	x	x	x
SAB-1/5	SAB-1	1,05	peat	x	x	x	x	x	x	x
SAB-1/6	SAB-1	1,2	silt *	x	x	x	x	x	x	x
SAB-1/7	SAB-1	1,4	thin-	x	x	x	x	x	x	x
SAB-1/8	SAB-1	1,6	lami-	x	x	x	x	x	x	x
SAB-1/9	SAB-1	1,8	nated	x	x	x	x	x	x	x
SAB-1/10	SAB-1	2	silt	x	x	x	x	x	x	x

Table 6-6: Samples for stable isotope analyses from Cape Sabler, Taymyr Peninsula, collected for the University Moscow during the expedition in 1996 (up. hor = upper horizon, 2. hor. = second horizon, bot. hor. = bottom horizon).

sample no.	study site	depth [m] or sample point	type of analyses 18-O	2-H	3-H [TU]	Character of sample	Ph
Is-96-1	valley	0,3	x	x	415	snow field	4,1
Is-96-2	SAO-1, IW-2	sample p. -1	x	x	41	ice wedge (up. hor.)	6,8
Is-96-3	SAO-1, IW-2	sample p. -2	x	x	18	ice wedge (up. hor.)	6,7
Is-96-4	SAO-1, IW-2	sample p. -3	x	x	41	ice wedge (up. hor.)	6,8
Is-96-5	SAO-1, IW-2	sample p. -4	x	x	<15	ice wedge (up. hor.)	6,8
Is-96-6	SAO-1, IW-2	sample p. -5	x	x	15	ice wedge (up. hor.)	6,8
Is-96-7	SAO-1, IW-2	sample p. -6	x	x	15	ice wedge (up. hor.)	6,7
Is-96-8	SAO-1, IW-2	sample p. -7	x	x	<15	ice wedge (up. hor.)	6,6
Is-96-9	SAO-1, IW-2	sample p. -8	x	x	<15	ice wedge (up. hor.)	6,8
Is-96-10	SAO-1, IW-2	sample p. -9	x	x	<15	ice wedge (up. hor.)	6,9
Is-96-11	SAO-1, IW-2	sample p. -10	x	x	<15	ice wedge (up. hor.)	7
Is-96-12	SAO-1, IW-2	sample p. -11	x	x	<15	ice wedge (up. hor.)	6,8
Is-96-13	SAO-1, IW-2	sample p. -12	x	x	<15	ice wedge (up. hor.)	6,8
Is-96-14	SAO-1, IB-1	sample p. -1	x	x	x	ice body (up. hor.)	x
Is-96-15	SAO-1, IB-1	sample p. -2	x	x	x	ice body (up. hor.)	x
Is-96-16	SAO-1, IB-1	sample p. -3	x	x	x	ice body (up. hor.)	x
Is-96-17	SAO-1, IB-1	sample p. -4	x	x	x	ice body (up. hor.)	x
Is-96-18	SAO-1, IW-3	sample p. -1	x	x	x	ice wedge (2. hor.)	x
Is-96-19	SAO-1, IW-3	sample p. -2	x	x	x	ice wedge (2. hor.)	x
Is-96-20	SAO-1, IW-3	sample p. -3	x	x	x	ice wedge (2. hor.)	x
Is-96-21	SAO-1, IW-3	sample p. -4	x	x	x	ice wedge (2. hor.)	x
Is-96-22	SAO-1, IW-3	sample p. -5	x	x	x	ice wedge (2. hor.)	x
Is-96-23	SAO-1, IW-3	sample p. -6	x	x	x	ice wedge (2. hor.)	x
Is-96-24	SAO-1, IW-3	sample p. -7	x	x	x	ice wedge (2. hor.)	x
Is-96-25	SAO-1, IW-3	sample p. -8	x	x	x	ice wedge (2. hor.)	x
Is-96-26	SAO-1, IW-3	sample p. -9	x	x	x	ice wedge (2. hor.)	x
Is-96-27	SAO-1, IW-3	sample p. -10	x	x	x	ice wedge (2. hor.)	x
Is-96-28	SAO-1, IW-3	sample p. -11	x	x	x	ice wedge (2. hor.)	x
Is-96-29	SAO-1, IW-3	sample p. -12	x	x	x	ice wedge (2. hor.)	x
Is-96-30	SAO-1, IW-3	sample p. -13	x	x	x	ice wedge (2. hor.)	x
Is-96-31	SAO-1, IW-3	sample p. -14	x	x	x	ice wedge (2. hor.)	x
Is-96-32	SAO-1, IW-3	sample p. -15	x	x	x	ice wedge (2. hor.)	x
Is-96-33	SAO-1, IW-3	sample p. -16	x	x	x	ice wedge (2. hor.)	x
Is-96-34	SAO-1, IW-3	sample p. -17	x	x	x	ice wedge (2. hor.)	x
Is-96-35	SAO-1, IW-3	sample p. -18	x	x	x	ice wedge (2. hor.)	x
Is-96-36	SAO-1, IW-3	sample p. -19	x	x	x	ice wedge (2. hor.)	x
Is-96-37	SAO-1, IW-3	sample p. -20	x	x	x	ice wedge (2. hor.)	x
Is-96-38	SAO-1, IW-3	sample p. -21	x	x	x	ice wedge (2. hor.)	x
Is-96-39	SAO-1, IW-3	sample p. -22	x	x	x	ice wedge (2. hor.)	x
Is-96-40	SAO-1, IW-3	sample p. -23	x	x	x	ice wedge (2. hor.)	x
Is-96-41	SAO-1, IW-3	sample p. -24	x	x	x	ice wedge (2. hor.)	x
Is-96-42	SAO-1, IW-3	sample p. -25	x	x	x	ice wedge (2. hor.)	x
Is-96-43	SAO-1, IW-3	sample p. -26	x	x	x	ice wedge (2. hor.)	x
Is-96-44	SAO-1, IW-3	sample p. -27	x	x	x	ice wedge (2. hor.)	x
Is-96-45	SAO-1, IW-3	sample p. -28	x	x	x	ice wedge (2. hor.)	x
Is-96-46	SAO-1, IW-4	sample p. -1	x	x	x	Ice Wedge (small)	x
Is-96-47	SAO-1, IW-4	sample p. -2	x	x	x	Ice Wedge (small)	x
Is-96-48	SAO-1, IW-5	sample p. -1	x	x	15	ice wedge (bot. hor.)	6,1
Is-96-49	SAO-1, IW-5	sample p. -2	x	x	17	ice wedge (bot. hor.)	6
Is-96-50	SAO-1, IW-5	sample p. -3	x	x	16	ice wedge (bot. hor.)	6,1
Is-96-51	SAO-1, IW-5	sample p. -4	x	x	<15	ice wedge (bot. hor.)	6,2
Is-96-52	SAO-1, IW-5	sample p. -5	x	x	<15	ice wedge (bot. hor.)	6

continuation next page

Table 6-6: continuation

sample no.	study site	depth [m] or sample point	type of analyses 18-O	2-H	3-H [TU]	Character of sample	Ph
Is-96-53	SAO-1, IW-5	sample p. -6	x	x	17	ice wedge (bot. hor.)	6,1
Is-96-54	SAO-1, IW-5	sample p. -7	x	x	15	ice wedge (bot. hor.)	6,2
Is-96-55	SAO-1, IB-1	s. point -3H-1	x	x	<15	ice body (up. hor.)	6,3
Is-96-56	SAO-1, IB-1	s. point -3H-2	x	x	44	ice body (up. hor.)	6
Is-96-57	SAO-1, IB-1	s. point -3H-3	x	x	72	ice body (up. hor.)	6
Is-96-58	SAO-1, IB-1	s. point -3H-4	x	x	134	ice body (up. hor.)	5,8
Is-96-59	SAO-1, IB-1	s. point -3H-5	x	x	34	ice body (up. hor.)	5,8
Is-96-60	SAO-1, IB-1	s. point -3H-6	x	x	33	ice body (up. hor.)	5,8
Is-96-61	SAO-1, IB-1	s. point -3H-7	x	x	26	ice body (up. hor.)	5,7
Is-96-62	SAO-1, IB-1	s. point -3H-8	x	x	24	ice body (up. hor.)	5,5
Is-96-63	SAO-1, IB-1	s. point -3H-9	x	x	20	ice body (up. hor.)	5,6
Is-96-64	SAO-1, IB-1	s. p. -3H-10	x	x	16	ice body (up. hor.)	5,8
Is-96-65	SAO-1, IB-1	s. p. -3H-11	x	x	17	ice body (up. hor.)	6
Is-96-66	SAO-1, IB-1	s. p. -3H-12	x	x	17	ice body (up. hor.)	6
Is-96-67	SAO-1, IW-6	sample p. -1	x	x	<15	ice wedge (head)	6,3
Is-96-68	SAO-1, IW-6	sample p. -2	x	x	<15	ice wedge (head)	6,4
Is-96-69	SAO-1, IW-6	sample p. -3	x	x	15	ice wedge (head)	6,4
Is-96-70	SAO-1, IW-6	sample p. -4	x	x	18	ice wedge (head)	6,4
Is-96-71	SAO-1, IW-6	sample p. -5	x	x	15	ice wedge (head)	6,4
Is-96-72	SAO-2, IW-1	sample p. -1	x	x	x	ice wedge (bot. hor.)	x
Is-96-73	SAO-2, IW-1	sample p. -2	x	x	x	ice wedge (bot. hor.)	x
Is-96-74	SAO-2, IW-1	sample p. -3	x	x	x	ice wedge (bot. hor.)	x
Is-96-75	SAO-2, IW-1	sample p. -4	x	x	x	ice wedge (bot. hor.)	x
Is-96-76	SAO-2, IW-1	sample p. -5	x	x	x	ice wedge (bot. hor.)	x
Is-96-77	SAO-2, IW-1	sample p. -6			x	ice wedge (bot. hor.)	x
Is-96-78	SAO-2, IW-1	sample p. -7	x	x	x	ice wedge (bot. hor.)	x
Is-96-79	SAO-2, IW-1	sample p. -8	x	x	x	ice wedge (bot. hor.)	x
Is-96-80	SAO-2, IW-1	sample p. -9			x	ice wedge (bot. hor.)	x
Is-96-81	SAO-2, IW-1	sample p. -10	x	x	x	ice wedge (bot. hor.)	x
Is-96-82	SAO-2, IW-1	sample p. -11	x	x	x	ice wedge (bot. hor.)	x
Is-96-83	SAO-2, IW-1	sample p. -12			x	ice wedge (bot. hor.)	x
Is-96-84	SAO-2, IW-1	sample p. -13	x	x	x	ice wedge (bot. hor.)	x
Is-96-85	SAO-2, IW-1	sample p. -14			x	ice wedge (bot. hor.)	x
Is-96-86	SAO-2, IW-1	sample p. -15	x	x	x	ice wedge (bot. hor.)	x
Is-96-87	SAO-2, IW-2	sample p. -1			x	ice wedge	x
Is-96-88	SAO-2, IW-2	sample p. -2	x	x	x	ice wedge	x
Is-96-89	SAO-2, IW-2	sample p. -3	x	x	x	ice wedge	x
Is-96-90	SAO-1	2,3-2,4			16	texture ice	6,7
Is-96-91	SAO-1	2,7-2,8			<15	texture ice	6
Is-96-92	SAO-1	2,8-2,9			<15	texture ice	6,1
Is-96-93	thermokarst lake		x	x	28	water	6
Is-96-94	streamlet		x	x	18	water	5,9
Is-96-95	rain 7.08.96				<15	water	6
Is-96-96	SAO-1, IW-7	sample p. -1			18	ice wedge (head)	6,4
Is-96-97	SAO-1, IW-7	sample p. -2			15	ice wedge (head)	6,4
Is-96-98	SAO-1, IW-7	sample p. -3			15	ice wedge (head)	6,4
Is-96-99	SAO-1, IW-7	sample p. -4			<15	ice wedge (head)	6,4
Is-96-100	SAO-1, IW-7	sample p. -5			15	ice wedge (head)	6,3
Is-96-101	SAO-1, IW-7	sample p. -6			<15	ice wedge (head)	6,2
Is-96-102	SAO-1, IW-7	sample p. -7			<15	ice wedge (head)	6,2
Is-96-103	SAO-1, IW-7	sample p. -8			<15	ice wedge (head)	6,4
Is-96-104	SAO-1, IW-7	sample p. -9			<15	ice wedge (head)	6,4
Is-96-105	SAO-1, IW-7	sample p. -10			<15	ice wedge (head)	6,3
Is-96-106	SAO-1, IW-7	sample p. -11			<15	ice wedge (head)	6,3
Is-96-107	SAO-1, IW-7	sample p. -12			<15	ice wedge (head)	6,3

continuation next page

Table 6-6: continuation

sample no.	study site	depth [m] or sample point	type of analyses 18-O	2-H	3-H [TU]	Character of sample	Ph
Is-96-108	SAO-1, IW-7	sample p. -13			<15	ice wedge (head)	6,2
Is-96-109	SAO-1, IW-7	sample p. -14			<15	ice wedge (head)	6,1
Is-96-110	SAO-1, IW-7	sample p. -15			<15	ice wedge (head)	6,2
Is-96-111	SAO-1, IW-7	sample p. -16			<15	ice wedge (head)	6,2
Is-96-112	SAO-1, IW-7	sample p. -17			<15	ice wedge (head)	6,3
Is-96-113	SAO-1, IW-7	sample p. -18			<15	ice wedge (head)	6,2
Is-96-114	SAO-1, IW-7	sample p. -19			<15	ice wedge (head)	6,3
Is-96-115	SAO-1, IW-7	sample p. -20			<15	ice wedge (head)	6,4
Is-96-116	SAO-1, IW-7	sample p. -21			<15	ice wedge (head)	5,9
Is-96-117	SAO-1, IW-7	sample p. -22			<15	ice wedge (head)	6,1
Is-96-118	SAO-1, IW-7	sample p. -23			<15	ice wedge (head)	6,1
Is-96-119	buried firn		x	x	<15	"ice cave"	6,3
Is-96-120	buried firn		x	x	<15	"SAO-2"	6,3
Is-96-121	buried firn		x	x	<15	"head"	6,2
Is-96-122	Taymyr Lake		x	x	<15	water	6,6

Table 6-7: Samples for radiocarbon dating from Cape Sabler, Taymyr Peninsula, collected for the University Moscow during the expedition in 1996.

sample no.	site no.	depth [m]	sample character	estimated age [yr BP]
Sb-96-1	SAO-1	0,7- 0,8	peat	<10.000
Sb-96-2	SAO-1	3,0-3,5	detritus, plant remains	10.000-20.000
Sb-96-3	SAO-1	5,0-6,0	peat, plant and wood remains	10.000-20.000
Sb-96-4	SAO-1	7,0-8,0	wood remains	10.000-20.000
Sb-96-5	SAO-1	10,0-10,5	detritus, plant remains	10.000-20.000
Sb-96-6	SAO-1	13,2	wood remains	20.000-30.000
Sb-96-7	SAO-1	15,0-15,5	detritus, wood remains	20.000-30.000
Sb-96-8	SAO-1	21,0	peat	20.000-30.000
Sb-96-9	SAO-1	23,3	detritus	30.000-40.000
Sb-96-10	SAO-1	25,0	detritus	30.000-40.000
Sb-96-11	SAO-3	1,2	peat, moss	<10.000
Sb-96-12	SAO-3	1,4	peat, moss	<10.000
Sb-96-13	SAO-3	2,65	peat, detritus	10.000-20.000 (?)
Sb-96-14	SAO-4	0,7-0,8	peat, wood remains	<10.000
Sb-96-15	SAO-5m	1,0-1,2	wood remains	5.000-10.000
Sb-96-16	SAO-5m	2,0-2,5	bones of mammoth	10.000-15.000
Sb-96-17	shore of Taymyr Lake (S-1g)		bones of mammoth	>10.000
Sb-96-18	shore of Taymyr Lake (S-2g)		bones of mammoth	>10.000
Sb-96-19	shore of Taymyr Lake (S-3g)		bones of mammoth	>10.000
Sb-96-20	shore of Taymyr Lake (S-4g)		bones of mammoth	>10.000

6.1.3 Water Samples from the Levinson-Lessing Lake Area

Table 6-8: Water samples from the Levinson-Lessing Lake area (LF = electrical conductivity; SPM = suspended matter; Isot. = Isotopes).

No.	Date 1996	Locality	Sample Type	Sample Vol. [ml]	Analyses: Anion	Analyses: Cation	Analyses: Isot. O, H	Analyses: SPM	Measurem.: LF [µS/cm]	Measurem.: Ph [-]
1	15.06.	slope 2x	snow	60	x	x	x			
2	19.06.	Lake A1 5m	water	60	x	x				
3	19.06.	Lake A1 10m	water	60	x	x				
4	19.06.	Lake A130m	water	60	x	x				
5	19.06.	Lake A115m	water	5000	x	x		x		
6	19.06.	Lake A2 5m	water	60	x	x				
7	19.06.	Lake A2 20m	water	5000	x	x		x		
8	19.06.	Lake A2 40m	water	60	x	x				
9	19.06.	Lake A2 60m	water	5000	x	x		x		
10	19.06.	Lake A3	ice	60			x			
11	21.06.	Lake A3 10m	water	250	x	x			62,4	
12	21.06.	Lake A3 30m	water	5000	x	x		x		
13	21.06.	Lake A3 45m	water	5000	x	x		x		
14	22.06.	Camp	soil water	30					60,6	
15	24.06.	Lake A6 20m	water	5000	x	x		x		
16	24.06.	Lake A6 40m	water	5000	x	x		x		
17	24.06.	Lake A6 60m	water	5000	x	x		x		
18	24.06.	Lake A8 10m	water	5000	x	x		x		
19	24.06.	Lake A8 30m	water	5000	x	x		x		
20	24.06.	Lake A8 45m	Water	5000	x	x		x		
21	24.06.	Camp	soil water	60	x	x			60,2	5,9
22	20.06.	Lake A2	snow	60			x			
23	26.06.	Camp	soil water	30	x	x			42,9	5,7
24	27.06.	Camp	soil water	30					49	6,4
25	27.06.	Krasnaya delta	water	1000	x	x		x		
26	27.06.	Krasnaya delta	water	1000	x	x		x		
27	27.06.	Lake A4 20m	water	5000	x	x		x	59	7,2
28	27.06.	Lake A4 40m	water	5000	x	x		x	56,8	7,4
29	27.06.	Lake A4 60m	water	5000	x	x		x	57,7	6,6
30	29.06.	Camp	soil water						60,8	6,3
31	29.06.	Lake A7 15m	water	5000			x	x	61,9	6,4
32	29.06.	Lake A7 30m	water	5000			x	x	57,4	6,9
33	29.06.	Lake A7 45m	water	5000			x	x	56,4	6,7
34	29.06.	Lake A6 20m	water	5000			x	x	35,7	6,5
35	29.06.	Lake A6 40m	water	5000				x	56,1	7,2
36	29.06.	Lake A6 60m	water	5000				x	56,3	6,7
37	29.06.	Lake A6	ice	60	x		x			
38	30.06.	Tundra	water	1000	x				44,6	6,4
39	01.07.	Lake A2 20m	water	5000				x	62,2	6,3
40	01.07.	Lake A2 40m	water	5000				x	56,9	6,6
41	01.07.	Lake A2 60m	water	5000				x	56,8	6,7
42	02.07.	Camp	water	60					36	7,7
43	03.07.	Lake H.Sp.	water	5000	x	x		x	53,7	7,3
44	03.07.	Stream 1	water	2000	x			x	50,3	6,8
45	29.06.	Lake A2 0,5m	water	250	x	x	x		17,1	5,9
46	03.07.	stream 1	water	250					64,7	
47	04.07.	stream 4	water	1000	x	x	x	x	23,7	6,2
48	04.07.	stream 3	water	1000	x	x	x	x	37,2	7,2
49	04.07.	stream 5	water	1000				x	37,6	6,5
50	04.07.	stream 2	water	1000	x	x	x	x	59,6	6,8
51	05.07.	Lake A2	ice	60			x			

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Table 6-8: continuation

No.	Date 1996	Locality	Sample Type	Sample Vol. [ml]	Analyses An-ion	Cat-ion	Iso-topes	SPM	Measurem. LF [µS/cm]	Ph [-]
52	05.07.	Lake A4 20m	water	5000	x	x	x	x	57,1	6,6
53	05.07.	Lake A4 40m	water	5000	x	x	x	x	59,1	6,8
54	05.07.	Lake A4 60m	water	5000	x	x	x	x	56,9	6,9
55	05.07.	Lake A6 20m	water	5000				x	60,1	7,2
56	05.07.	Lake A6 40m	water	5000				x	57	6,9
57	05.07.	Lake A6 60m	water	5000				x	57,2	7,1
58	07.07.	Lake A2 20m	water	5000	x	x		x	59,8	7,2
59	07.07.	Lake A2 40m	water	5000	x	x		x	57	7,6
60	07.07.	Lake A2 60m	water	5000	x	x		x		
61	08.07.	stream 1	water	1000	x		x	x	57,6	7,6
62	08.07.	stream 6	water	1000	x	x		x	55,1	7,6
63	08.07.	stream 7	water	1000	x	x		x	34,2	7,7
64	11.07.	stream 3	water	2000	x	x		x	56	7,2
65	11.07.	stream 8	water	2000	x	x		x	57,8	6,8
66	06.07.	Protochni	water	60					59,8	7,2
67	11.07.	Protochni	water	60					55,8	7,3
68	12.07.	Protochni	water	60			x		56,3	7,4
69	13.07.	Protochni	water	60					52,6	7,4
70	14.07.	Protochni	water	60			x		56,8	7,2
71	16.07.	Lake Thermok.	water	250	x	x			85,4	7,3
72	16.07.	Camp	soil water	60	x				262	6,5
73	17.07.	stream 3	water	1000	x	x	x	x	61,8	7,2
74	17.07.	stream 8	water	1000	x	x	x	x	69,7	7,5
75	20.07.	stream 1	water	750	x	x	x	x	90	7,9
76	20.07.	stream 6	water	1000	x	x	x	x	95,9	7,9
77	20.07.	stream 9	water	1000	x	x		x	84,2	7,3
78	20.07.	stream 10	water	1000	x	x		x	179	7,5
79	20.07.	slope 2x	soil water	20ml	x		x			
80	20.07.	slope 2x	soil water	20	x		x			
81	20.07.	slope 2x	soil water	20	x		x			
82	24.07.	stream 8	water	1000	x	x		x	72	7,6
83	24.07.	stream 3	water	2000	x	x		x	77,8	7,6
84	24.07.	stream 2	water	1000	x	x		x	77,2	7,6
85	25.07.	slope 2x	soil water	60	x		x		915	7,6
86	25.07.	slope 2x	soil water	40			x			
87	25.07.	slope 2x	soil water	20			x			
88	25.07.	slope 2x	soil water	20			x			
89	25.07.	stream 1	water	250			x		115	7,9
90	25.07.	Protochni	water	150			x		52,5	7,6
91	27.07.	Thermokarst	sediment					x		
92	27.07.	slope 2x	soil water	20						
93	30.07.	slope 3A	soil water	60	x		x		142	6,8
94	30.07.	slope 3B	soil water	60	x		x			6,6
95	31.07.	slope 2x	soil water	60	x				1087	7,7
96	31.07.	slope 2x	soil water	60	x				853	7,8
97	31.07.	slope 2x	soil water	50	x		x			
98	31.07.	slope 2x	soil water	60	x		x			
99	31.07.	stream 1	soil water	1000	x		x	x	95,1	8,4
100	31.07.	camp	rain						30,4	6,5
101	01.08.	stream 6	water	2000	x		x	x	142	7,7
102	01.08.	camp	rain	1500	x	x	x		42,5	4,9
103	01.08.	camp	rain	2000	x	x	x		7,8	5,3
104	02.08.	Lake A8 15m	water	5000	x	x	x			
105	02.08.	Lake A8 30m	water	5000	x	x	x		56	6,8
106	02.08.	Lake A8 45m	water	5000	x	x	x			

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Table 6-8: continuation

No.	Date 1996	Locality	Sample Type	Sample Vol. [ml]	Analyses An-ion	Cat-ion	Iso-topes	SPM	Measurem. LF [µS/cm]	Ph [-]
107	04.08.	camp	rain						7,1	5,4
108	05.08.	Camp	rain						2,8	6,0
109	06.08.	slope 2x	soil water	300	x	x	x		1270	7,3
110	06.08.	slope 2x	soil water	400	x	x	x		1469	7,8
111	08.08.	stream 3	water	1000	x	x		x	156	8,9
112	08.08.	stream 8	water	1000		x		x	183	8,8
113	08.08.	Lake A4 20m	water	5000	x	x		x	57,3	6,6
114	08.08.	Lake A4 40m	water	5000	x	x		x	57,9	6,9
115	08.08.	Lake A4 60m	water	5000	x	x		x	57,5	7,8
116	14.08.	Camp	snow	60			x			

6.1.4 Lake sediment Samples from the Taymyr Peninsula

Table 6-9: Lake sediment samples collected 1996 from Levinson-Lessing Lake and from thermokarst lakes in its sourroundings (recov.= recovery; Less. = Lessing; core 1259 was taken from a site, where 1995 the 22.4 m long core PG1228 was recovered).

Core No.	Locality	position Latitude	Longitude	water depth [m]	gear	recov. [cm]	analyses
PG1247	Thermokarst			0,8	SL	13,0	geochemistry
PG1248	Thermokarst			0,7	SL	16,5	geochemistry
PG1249	Levinson-Less.	74°32' 99	98°36'22"	55,0	SL	22,0	geochemistry
PG1250	Levinson-Less.	74°32'02"	98°36'84"	30,0	SL	20,5	geochemistry
PG1251	Levinson-Less.			55,0	SL	34,0	geochemistry
PG1252	Levinson-Less.			60,0	SL	16,0	geochemistry
PG1253	Levinson-Less.	Krasnaja	Delta	28,0	SL	21,5	geochemistry
PG1254	Levinson-Less.	74°30'70"	98°35'87"	75,0	SL		geochemistry
PG1255-1	Levinson-Less.	74°31'09"	98°34'89"	60,0	SL	31,0	geochemistry
PG1255-9	Levinson-Less.	74°31'44"	98°33'98"	10,0	SL	21,0	geochemistry
PG1256	Levinson-Less.	Krasnaja	Delta	18,0	SL	8,0	geochemistry
PG1257	Levinson-Less.			70,0	SL	23,0	CH4; pore water
PG1258	Levinson-Less.	74°28'19"	98°40'92"	105,0	SL	25,0	geochemistry
PG1259	Levinson-Less.	74°28'40"	98°38'35"	108,0	SL	25,0	geochemistry
PG1260	Levinson-Less.	74°27'51"	98°42'39"	95,0	SL	17,0	geochemistry
PG1261	Levinson-Less.			85,0	SL	18,0	geochemistry
PG1262	Levinson-Less.			73,0	SL	18,5	geochemistry
PG1263	Levinson-Less.			20,0	SL	20,0	geochemistry
PG1264	Levinson-Less.			60,0	SL	24,0	geochemistry
PG1265	Levinson-Less.	74°28'29"	98°38'86"	100,0	SL	23,0	geochemistry
PG1266	Levinson-Less.	74°28'22"	98°38'69"	103,0	SL	31,0	geochemistry
PG1267	Levinson-Less.	74°28'20"	98°38'35"	103,0	SL	25,0	geochemistry

6.1.5 Hydrological Measurements on Severnaya Zemlya

Table 6-10: In situ measurements of hydrological parameters carried out on June 25, 1969, at sampling site PG1239 in Changeable Lake (for location see Fig. 3-22); water depth is 17.3 m, temp. are shown as the mean of all three probes.

sample depth [m]	temperature [°C]	pH	conductivity [µS/cm]	diss. oxygen [mg/l]
0.2	0.0	8.28	230	19.4
1.0	0.0	8.28	230	20.8
2.0	0.0	8.28	230	13.4
3.0	0.0	8.27	229	11.3
4.0	0.1	8.27	229	10.9
5.0	0.1	8.27	229	10.7
6.0	0.1	8.27	229	10.6
7.0	0.1	8.27	234	10.8
8.0	0.2	8.25	245	11.5
9.0	0.2	8.25	258	12.3
10.0	0.3	8.23	277	14.1
11.0	0.3	8.22	294	14.7
12.0	0.3	8.22	309	18.5
13.0	0.4	8.19	342	17.9
14.0	0.4	8.17	371	15.7
15.0	0.5	8.15	449	16.3
16.0	0.5	8.11	483	15.9
16.5	0.6	8.02	500	12.0
16.8	0.6	7.91	506	8.3
17.0	0.6	7.86	514	5.4
17.2	0.7	7.84	521	2.9
17.3	0.7	7.85	423	1.9

Table 6-11: In situ measurements of hydrological parameters carried out on July 1, 1996, at sampling site PG1240 in Fjord Lake (for location see Fig. 3-24); water depth is 70.8 m, temperatures are shown as the mean of two probes.

sample depth [m]	temperature [°C]	pH	conductivity [µS/cm]	diss. oxygen [mg/l]
0.2	0.0	6.55	51.8	14.4
2.0	0.0	7.76	112.4	14.4
5.0	0.0	7.91	117.6	16.6
10.0	0.0	7.84	119.6	19.7
15.0	0.0	7.96	120.8	23.0
20.0	0.0	7.96	121.4	21.2
25.0	0.0	7.99	121.2	20.7
30.0	0.0	7.96	121.0	20.7
35.0	0.0	7.98	121.4	20.1
40.0	0.0	7.95	122.2	19.5
45.0	0.0	7.98	121.9	19.4
50.0	0.0	7.97	123.0	19.3
55.0	0.0	7.98	122.9	18.9
60.0	0.0	7.94	122.4	18.6
65.0	0.0	8.01	124.5	18.3
67.0	0.0	7.93	124.1	18.2
69.0	0.0	8.01	124.1	17.8
70.0	0.0	8.01	124.1	17.4
70.5	0.0	8.01	124.4	17.3

Table 6-12: In situ measurements of hydrological parameters carried out on July 5, 1996, at sediment sampling site PG1242 in Fjord Lake (for location see Fig. 3-24); water depth is 55.4 m, temperatures are shown as the mean of all three probes.

sample depth [m]	temperature [°C]	pH	conductivity [µS/cm]	diss. oxygen [mg/l]
0.2	0.3	7.09	50.2	16.4
2.0	0.0	7.43	121.0	18.3
5.0	0.0	7.94	120.5	18.1
10.0	0.0	8.04	120.5	19.3
20.0	0.0	7.85	119.3	19.8
30.0	0.0	8.01	118.5	19.5
40.0	0.0	7.77	117.8	19.5
45.0	0.0	7.87	117.4	18.8
48.0	0.0	8.04	117.4	17.8
51.0	0.0	7.91	117.4	17.6
54.0	0.0	7.96	117.8	17.0
55.0	0.0	8.03	118.3	17.0

6.2 Lists of Participating Institutions and Scientists

Table 6-12: Participating institutions on the Expedition Taymyr/Severnaya Zemlya 1996.

abbreviation	institute name and adress	no. of participants
AARI	Arctic and Antarctic Research Institute Department of Polar Geography Bering Street 38 199 226 St. Petersburg Russia	11
AWI	Alfred Wegener Institute for Polar and Marine Research Columbusstrasse D-27568 Bremerhaven Germany	1
	and Alfred Wegener Institute for Polar and Marine Research Research Unit Potsdam Telegrafenberg A43 D-14473 Potsdam Germany	7
IBH	Institute of Soil Sciences University of Hamburg Allende-Platz 2 D-20146 Hamburg Germany	4

Continuation nect page

Table 6-12: Continuation

abbreviation	institute name and adress	no. of participants
IMC	Institute for Material Culture History St. Petersburg Russia	1
IPÖ	Institute of Polar Ecology University of Kiel Wischhofstr. 1-3 D-24148 Kiel Germany	3
ISSP	Institute for Soil Sciences and Photosynthesis Russian Academy of Sciences 142 292 Pushchino Russia	1
KBI	Komarov Botanical Institute Russian Academy of Sciences Prof. Popov Street 197 376 St. Petersburg Russia	3
LU	Lund University Department of Quaternary Geology Sölvegatan 13 S-22362 Lund Sweden	2
MSU	Moscow State University Department of Permafrost Studies Faculty of Geology 119 899 Moscow Russia	2
RINCAN	Research Institute for Nature Conservation of the Arctic and the North Tovaryshesky 28 St. Petersburg Russia	1
UHW	Martin Luther University Halle-Wittenberg Institute of Geography Domstr. 5 D-06108 Halle Germany	2

Table 6-13: Participating scientists on the Expedition Taymyr/Severnaya Zemlya 1996 (for institute abreviations see Table 6-12, for expedition parts see Chapter 1.2).

Participant	Institute	Expedition area and part
Anisomov, Mikhael A.	AARI	Taymyr Peninsula, part 1, part 2, and part 3
Antonov, Oleg M.	AARI	Taymyr Peninsula, part 1 and part 2
Aparin, Svea	KBI	Severnaya Zemlya, part 2
Becker, Holger	IBH	Taymyr Peninsula, part 2 and part 3
Bölter, Manfred	IPÖ	Severnaya Zemlya, part 2
Bolshiyanov, Dmitri Yu.	AARI	Severnaya Zemlya, part 1; Taymyr Peninsula, part 2
Carlemalm, Gunnar	LU	Taymyr Peninsula, part 2
Derevyagin, Alexander Yu.	MSU	Taymyr Peninsula, part 2
Ebel, Tobias	AWI	Taymyr Peninsula, part 1 and part 2
Federov, Grigori B.	AARI	Taymyr Peninsula, part 2
Gintz, Dorothea	UHW	Taymyr Peninsula, part 1 and part 2
Gundelwein, Andreas	IBH	Taymyr Peninsula, part 2 and part 3
Hagedorn, Birgit	AWI	Taymyr Peninsula, part 1 and part 2
Ivanov, Andrey Yu.	AARI	Taymyr Peninsula, part 1 and part 2
Kirtsedele, Irina	KBI	Taymyr Peninsula, part 1 and part 2
Kopsch, Conrad	AWI	Taymyr Peninsula, part 2
Meinel, Tobias	UHW	Taymyr Peninsula, part 1 and part 2
Melles, Martin	AWI	Severnaya Zemlya, part 1
Melnikov, Alexey	AARI	Severnaya Zemlya, part 1
Mescherjakov, Viktor G.	AARI	Severnaya Zemlya, part 1 and part 2
Möller, Per	LU	Taymyr Peninsula, part 2
Müller-Lupp, Thomas	IBH	Severnaya Zemlya, part 1; Taymyr Peninsula, part 2
Niessen, Frank	AWI	Taymyr Peninsula, part 2
Panasenkova, Olga	RINCAN	Taymyr Peninsula, part 2
Pavlov, Oleg	AARI	Severnaya Zemlya, part 1
Pfeiffer, Eva-Maria	IBH	Severnaya Zemlya, part 2
Pitul´ko, Vladimir V.	IMC	Taymyr Peninsula, part 2
Romaschenko, Oxana G.	AARI	Taymyr Peninsula, part 1 and part 2
Ryazanova, Masha V.	AARI	Taymyr Peninsula, part 1 and part 2
Samarkin, Vladimir A.	ISSP	Severnaya Zemlya, part 1; Taymyr Peninsula, part 2
Schmidt, Nicole	IPÖ	Taymyr Peninsula, part 2
Sommerkorn, Martin	IPÖ	Taymyr Peninsula, part 2
Troshin, E.V.	MSU	Taymyr Peninsula, part 2
Ufimtsev, Alexander V.	AARI	Taymyr Peninsula, part 1, part 2, and part 3
Vannahme, Gerald	AWI	Taymyr Peninsula, part 1 and part 2
Wilmking, Martin	AWI	Severnaya Zemlya, part 1
Zhurbenko, Mikhael P.	KBI	Severnaya Zemlya, part 2
Zielke, Artur	AWI	Severnaya Zemlya, part 1