## 3.10 Paleoecological and sedimentological studies of Permafrost deposits in the Central Lena Delta (Kurungnakh and Samoylov Islands)

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### 3.10.1 Introduction

The geological research in the Lena Delta on Kurungnakh (site No. 1: 72° 20' 41" N, 126° 18' 33" E; site No. 2: 72°, 20' 35" N, 126° 18' 20" E) and Samoylov Islands (Figure 3-38) in 2002 was carried out by tree scientists. The main tasks of this small team were:

- cryolithological description of the sections
- sampling of sediments for multi-proxy analysis (e.g. pollen, ostracods, geochemistry, sedimentology) and age determination
- screening sediment for fossil insects
- collection of mammal bones
- determination of the ice content the in the frozen sediments
- taking of ice wedge samples for stable isotope and hydrochemistry analyses by means of an ice screw

The Buor Khaya section on the Kurungnakh Island was the main object of field studies. Besides that we studied two Holocene sections on Samoylov Island. The methods of geological and paleontological investigations were similar as described in the previous expedition reports (Siegert et al., 1999; Sher et al., 2000, 2002). In addition, some other places within the Lena delta were used for recent ecological studies (e.g. Tit-Ary, Sokol).

The Buor Khaya section on the Kurungnakh Island was previously examined by the participants of the Russian-German expeditions "Lena Delta 98, 99, 2000, 2001". (Schwamborn, 1999; Pavlova & Dorozhkina, 2000; Kuznetsova & Kuzmina, 2001; Schirrmeister et al., 2001; Pfeiffer et al., 2002). But for the first time it was possible to study these profiles in more detail. There are a number of age-determinations by radiocarbon and Optic Stimulated Luminescence (OSL) dating and results of sedimentological studies (Schwamborn et al., 2002, Krbetschek et al., 2002). But the sediments have never been screened for fossil insects. During previous research on the Samoylov Island the surface sediments were cored and described (Pfeiffer et al., 2002).

### 3.10.2 Geological description of the Buor Khaya section (Kurungnakh Island) and two Holocene sections (Samoylov Island)

Chronology

Like in some other Lena Delta sites (Lungersgausen, 1961; Kunitsky, 1989; Grigoryev, 1993), the Quaternary deposits of the Buor-Khaya section are represented by two main units. The lower unit consists sandy deposits corresponding to the stratigraphic locally named Bulukur-Suite. The upper unit

is the ice-rich Kobakh-Suite. In this report we use the more common names "Ice Complex" or "Yedoma" for these ice-rich deposits. The sandy unit was dated from 65 to 88 ka BP by the IR-OSL method and from 57 to 37 ka BP by AMS (Schwamborn, 2002). The contradictions of age determinations by different methods are still under discussion (Grosse et al., 2002). The upper ice-rich unit was dated from 50 to 33 ka BP and 17 ka BP in the uppermost part of the Ice Complex. The top of the Buor Khaya section was dated to 7.7 ka BP (Schirrmeister et al., submitted).

Kurungnakh Island

The sands of the Bulukur-Suite are well exposed along the whole section. In some places, especially in the lower part, the sands contain abundant roots and stems of large grasses, probably of *Arctophila fulva*. The exposed "*Arctophila*"-rich sand usually forms very steep or even vertical walls. We observed a similar situation in the Nagym section in the North of the Olenyok Channel (Schirrmeister et al., 2001). The middle part of the sandy unit usually contains silt layers with plant detritus. The upper part of the Bulukur-Suite is built mostly by clean (washed out) sand with little organic material (Table 3-20). Only in some places we found thin layers of fine plant detritus. Thus, the sandy unit consists of the different facies, changing in vertical and horizontal directions. The Bulukur-Sands were studied at site No.2 (Figure 3-401).

**Table 3-20.** Description of the lower unit (Bulukur-Suite) at the Kurungnakh section.

| Altitude [m, a.r.l] | Description |
|---|---|
| 17.2-17.5 | grey fine-grained sand (probably a buried soil layer) |
| 10.5-17.2 | yellow medium- and coarse-grained sand without visible stratification |
| 7-10.5 | intercalation of yellow clean fine-grained sand and grey silty sand with plant detritus; individual layers are up to 0,1-0,15 m thick |
| 5-7 | yellow medium-grained sand without visible stratification |
| 0-5 | slope debris: sand from the upper part of Bulukur-Suite, peat blocks and liquid mud from ice-rich Ice Complex |

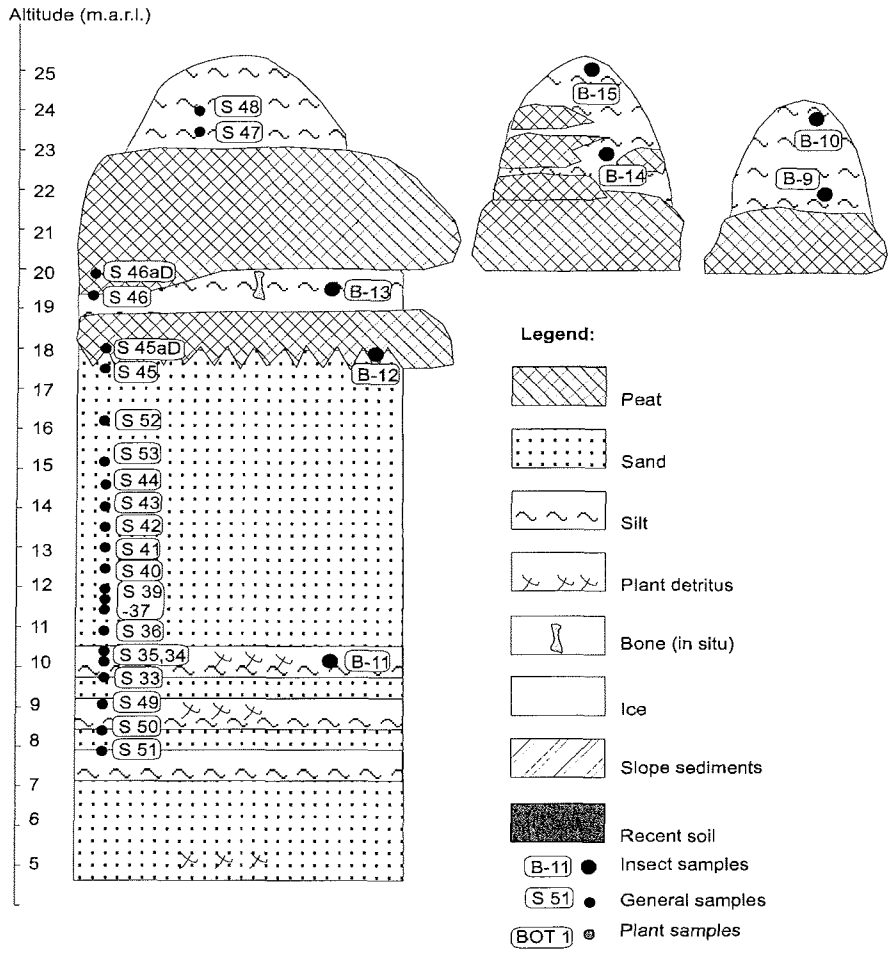


**Figure 3-40.** Kurungnakh section, site No. 2, Bulukur-Suite and the low part of Yedoma.

The Bulukur-Sands are covered by Ice Complex deposits - ice-rich silt with thick peat horizons, sand lenses and large ice wedges. The boundary between the Bulukur-Suite and Ice Complex is sharp and visible along the whole section (Figure 3-41). The Ice Complex ice wedges sharply narrow near the boundary with the Bulukur-Suite, and their long and narrow tails penetrate 2-3 m into the sand. In 2000, special ice wedges were found and sampled within the Bulukur-Sands (Schirrmeister et al., 2001, p. 95, fig. 5-9, Schirrmeister et al. submitted), but in 2002 we could not observe ice wedges belonging to the Bulukur-Suite. In the Buor Khaya section, the Ice Complex unit is often exposed like an ice wall along the river-bank. This wall, being up to 1 km long, is probably a longitudinal section of the polygonal ice-wedge system. The ice wall is covered by overhanging blocks of peat with frozen silt. These blocks fall down if the underlying ice thaws, and roll down to the Lena bank (Figure 3-41).

Consequently, we could take samples from a block if the place of its original position was evident.

**Figure 3-41.** Kurungnakh section: Bulukur-Suite and the low part of Yedoma.

The Ice Complex sediments are mostly ice-rich silt with thick peat layers (Table 3-21). The thickest peat layers are observed in the lower part of the Ice Complex. At least three of such layers are clearly observed along the section. In the upper part of the section the peat layers are more rare and less thick. Sandy layers or lenses are often observed near the boundary ice wedge - sediment.

**Table 3-21.** Description of the Ice Complex sediments at the site No. 1 from the top.

| Depth [m] | Description |
|---|---|
| 0-0.2 | soil layer |
| 0.2-2.5 | grey silt with brown peat hummocks (0.1x 0.15 m) - point 1 |
| 2.5-3.2 | Ice |
| 3.2-5.7 | grey silt with plant detritus – baydzherakhs B and C |
| 5.7-6.5 | yellow medium-grained sand near ice wedge – Baydzherakh C |
| 6.0-6.7 | grey silt with plant detritus – baydzherakh E |
| 6.7-7.2 | reddish-brown peat – baydzherakh E |
| 7.2-9.2 | grey silt with plant detritus – baydzherakh E |
| 9.2-11.5 | grey sandy silt with grass roots and woody twigs – baydzherakhs F, G, H |
| 11.5-12.2 | brown peat – baydzherakh H |
| 12.2-13.2 | grey silt – baydzherakh H, G, P |
| 13.2-15.7 | brown peat, third (from the bottom) marker horizon in the vertical wall |
| 15.7-19.0 | grey silt with plant detritus |
| 19.0-21.5 | grey silt with abundant peat lenses and spots |
| 21.5-23.2 | brown peat, the second marker horizon in the vertical wall |
| 23.5-24.8 | grey silt with plant detritus |
| 24.8-26.5 | brown peat, the first marker horizon in the vertical wall |

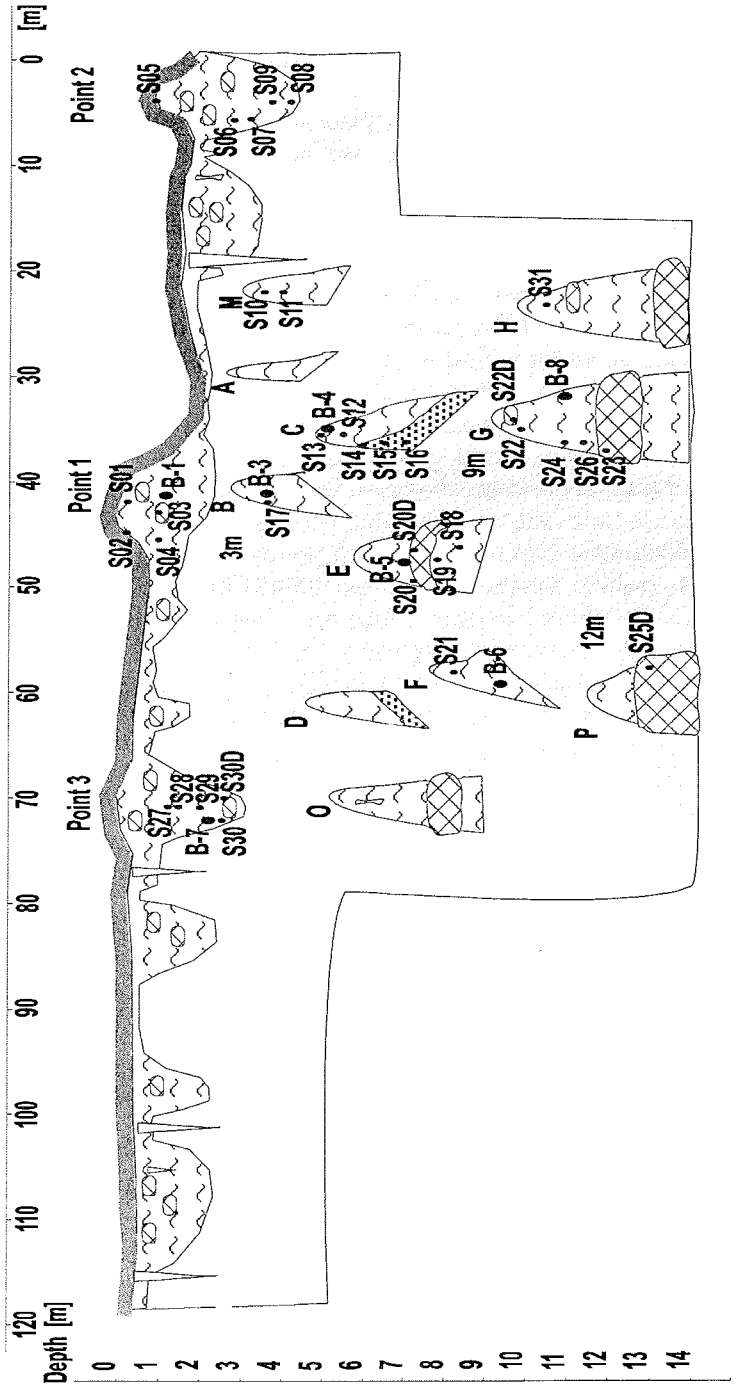


**Figure 3-42.** Kurungnakh section, site No. 1, Yedoma-Suite.

In the top part of the section, under the active layer, we found a horizon of silt with peat hummocks presumably of the Holocene age. The thickness of this horizon amounts from 0.1 - 0.2 m to 2 m. Small Holocene ice wedges are present here, which often penetrate into the much larger Pleistocene ice wedges (Figure 3-42). A similar situation was observed at the top of the Ice Complex sections on the Bykovsky Peninsula and on Bol'shoy Lyakhovsky Island.

Samoylov Island

In addition, two sections were studied on the Samoylov Island. Section 1 is situated on the bank, 90 m SSE of the camp (the river upstream) on the first terrace above the floodplain, which is built up mostly by peat (Table 3-22) and contains a series of Holocene ice wedges. A site was chosen, where the ice wedges were well- exposed and could be studied best (Figure 3-43). At this site on the South coast of Samoylov Island, a Holocene ice wedge of the first terrace (SAM-IW-1) in the Lena Delta was sampled and described in detail. The ice wedge is 1.4 m wide and 2.2 m high, and because of its preferential thawing, situated approximately 5 m behind the cliff above the Lena river. It is cut perpendicular to its growth direction and characterised by yellowish-white and milky ice with well-developed vertical structures. Single elementary ice veins are 2-3 mm wide, but not easy to differentiate, and contain a lot of small gas bubbles (< 1 mm). At the left side, the ice wedge is limited by clear and transparent ice. At 20 cm from this side, the upper part of a small ice vein continues into the overlying sediment layer. The ice wedge shows a number of cracks, which extend from the upper left to the lower right side of the wedge. These seem to be linked to other processes than frost cracking e.g. tectonic influence, but the reason is still unknown, yet. A number of 17 samples was taken from a 1.4 m long horizontal sampling transsect in a height of 7.0 m a.s.l.. These samples were poured into 30 ml PE bottles, which were closed tightly and sealed with special tape to avoid evaporation of the samples. The samples will be measured for stable oxygen and hydrogen isotope composition at AWI Potsdam.

**Table 3-22.** Description of the section No. 1 from the Samoylov Island.

| Altitude [m, a.r.l] | Description |
|---|---|
| 8.0-7.8 | soil layer |
| 7.8-7.3 | Horizon I-yellow and greyish-yellow medium grained sand with peat lenses (above the ice wedge) and fine layers (aside of the top of the ice wedge), peat consists of moss and grass stems, the grass is probably Arctophila fulva |
| 7.3-5.7 | Horizon II-peat, near the ice wedge turns into peaty silt, brownish-grey silt with woody roots and twigs and relatively large pieces of wood, brown peat, mostly consists of green moss with sedges and "Arctophila" grass, the top of the peat layer has a reddish-brown band of green moss peat. |
| 5.7-5.4 | Horizon III-greyish-yellow medium grained sand with grass roots |
| 0-5.4 | slope debris |

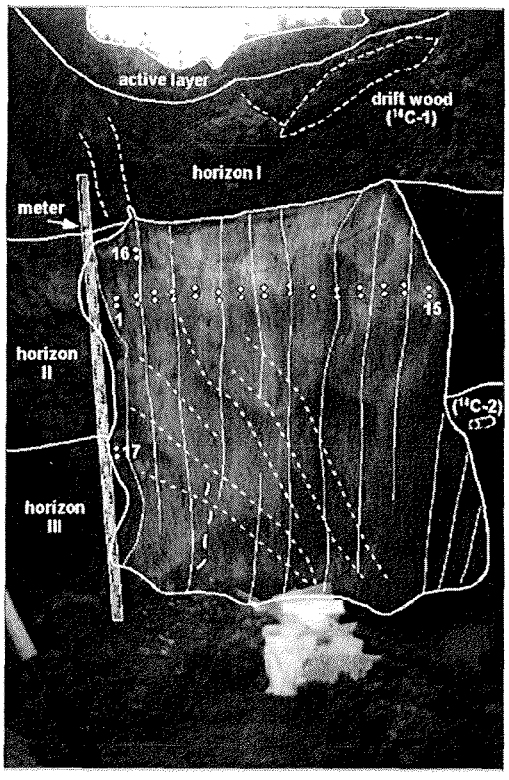


**Figure 3-43.** Holocene ice wedge in section No. 1on Samoylov Island.

The section No. 2 is the first terrace above the floodplain on Samoylov Island and is composed of silty sand (Table 3-23). The site is situated at the Lena bank, 500 m SSE of the camp. The lower part of the exposure has a wave-cut niche, covered by debris. The upper part is an almost vertical wall, because of abundant plant remains: woody twigs, roots, wood fragments, grass stems, preventing erosion (Figure 3-44).

**Table 3-23.** Description of the section No. 2 from the Samoylov Island.

| Altitude [m, a.r.l] | Description |
|---|---|
| 8.0-7.8 | soil layer |
| 7.8-7.2 | horizon I-grey fine-grained sand with plant detritus and thin (3-5 cm) layers of yellow clean medium-grained sand |
| 7.2-6.5 | horizon II-grey fine-grained sand with lenses of plant detritus, wood fragments, grass roots and stems |
| 6.5-5.5 | horizon III-grey silt with woody twigs and roots, plant detritus |
| 0-5.5 | slope debris |

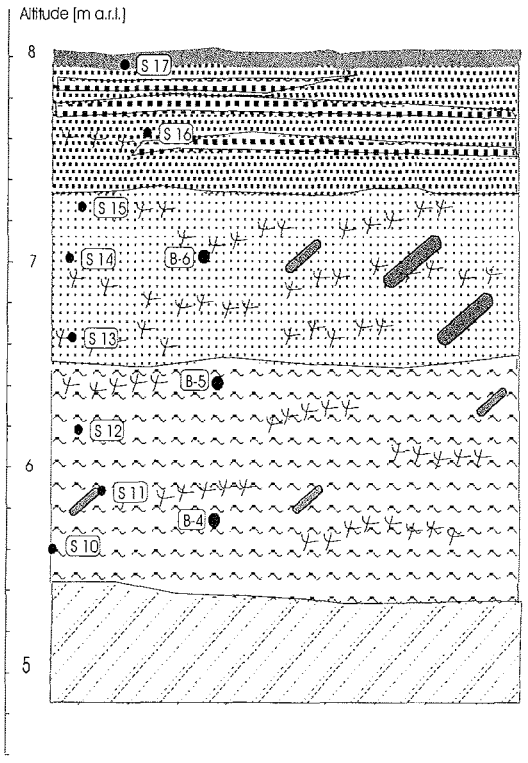


**Figure 3-44.** section No. 2 on Samoylov Island.

### 3.10.3 Sampling of permafrost sediment and ice

The samples from the permafrost were taken by knife or axe. In the upper part of the section (Ice Complex unit) we could take samples along a stratigraphic vertical sequence of thermokarst mounds (baydzherakhs) with overlapping tops and bottoms (Figure 3-42). Samples for pollen analyses, ice content determination, sedimentological analysis and ostracod studies were taken separately. Additionally, peat layers were sampled for conventional radiocarbon dating (Appendix 3-9). The ice content was determined gravimetrically on a dry-weight basis, as the ratio of the mass of ice in a sample to the mass of the dry sample, expressed as a percentage (van Everdingen, 1998).

For stable isotope and hydrochemical analysis samples were taken from one Holocene ice wedge penetrating into an older Pleistocene ice wedge in the upper part of the Ice Complex unit (Appendix 3-11, Figure 3-45). We used ice screws to drill a transverse across the ice wedge, in a distance between the drill-holes of about 0.07 m (on three levels) for the this ice wedge. Altogether we get 13 samples for stable isotope analysis and 2 samples for hydrochemical

analysis from the first ice wedge. Ice samples were also taken from an ice wedge in the lower part of the section (Appendix 3-11, Figure 3-46), where ice wedges from the Ice Complex penetrate into the underlying sands of the Bulukur – Suite. Next to the ice wedge we found horizontal layered ground ice. Along a transverse across the ice wedge and the ground ice in a distance between the drill-holes of about 0.1 m (on one level) were taken 12 samples for stable isotope analysis and 2 samples for hydrochemical analysis. After melting the ice samples were poured into 15-ml-HDPE bottles. The samples for anion hydrochemical analyses were conserved by freezing and for cation hydrochemistry analyse were conserved with 25 µl $HNO_3$.

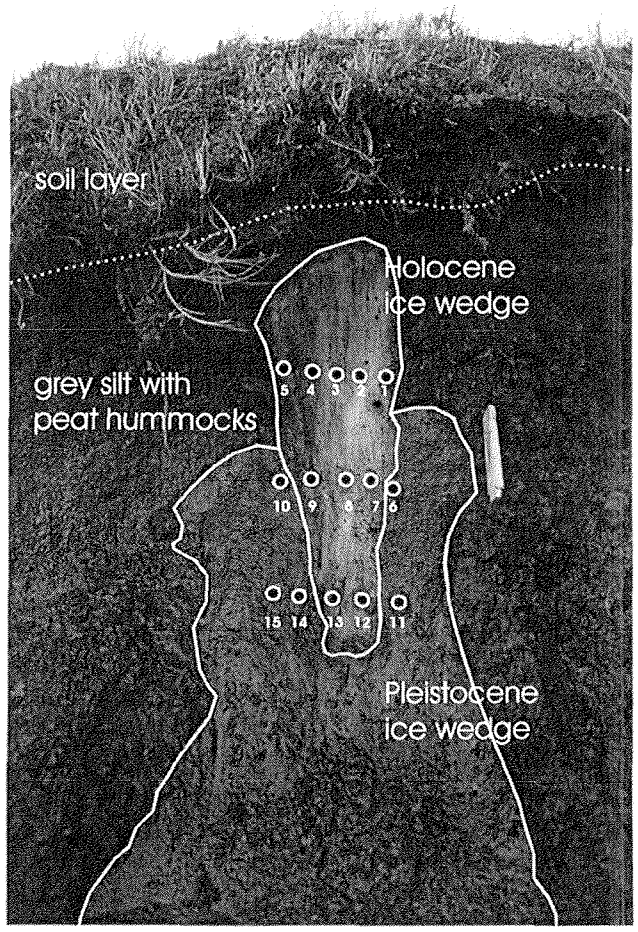


**Figure 3-45.** Holocene ice wedge in the upper part of the Ice Complex unit on Kurungnakh Island.

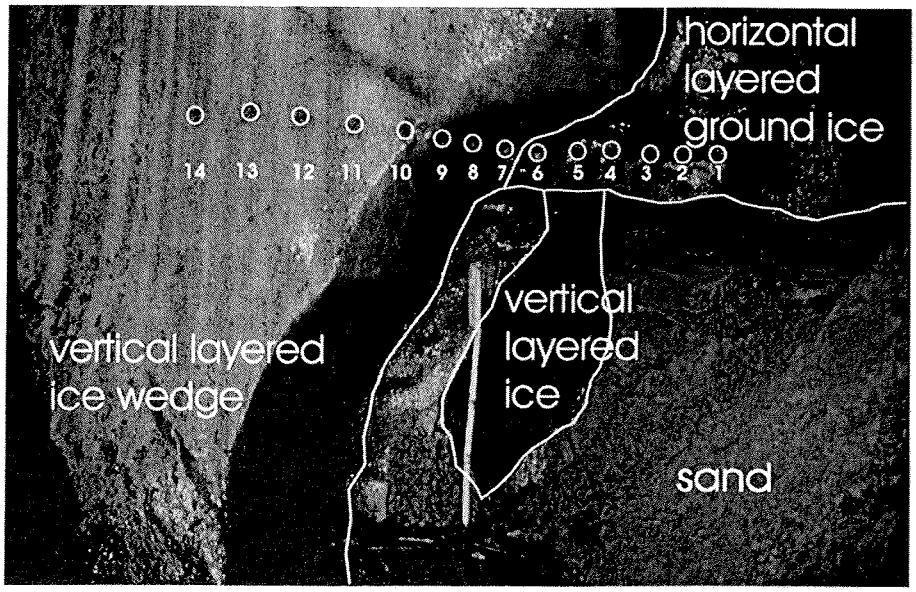


**Figure 3-46.** Ice wedge in the Bulukur-Suite on Kurungnakh Island.

### 3.10.4 Screening sediment for insect fossils

In contrast to the previous year, almost all fossil insect samples were taken from thawed sediment in 2002 (Sher et al., 2002). Only one sample (BKh-2002-B7) was chopped by axe from frozen deposits. In this case it was sufficient to take about 30 kg of sediment, instead of 50 kg normally, because insect remains were rather abundant in the screened detritus. Usually, a preliminary screening showed a low content of insect fossils. In these cases, up to 200 kg of sediment were screened.

In the Buor Khaya section, one sample (BKh-02-B1) was screened from the upper, presumably Holocene layer. Nine samples (BKh-02-B2 – B8, B12, B13) were taken from the Ice Complex baydzherakhs (Figure 3-40), four samples (BKh-02-B9, B10, B14, B15) - from two fallen blocks of frozen Ice Complex sediments; one sample (BKh-02-B11) from the Bulukur-Suite (Figure 3-42). From Samoylov Island three samples (Sam-B1 – B3) were taken from the section No.1 (Figure 3-43) and three samples (Sam-B4 – B6) from the section No. 2 (Figure 3-44). In total, we took and screened 15 samples from Buor Khaya site and 6 samples from Samoylov Island (Appendix 3-12).

### 3.10.5 Collection of mammal bones

Mammal bones were collected during the whole field studies. Following the tradition of 1998-2000 field seasons, we tried to collect all bones found, except evidently indeterminable pieces. In Moscow, Dr. A. Sher helped to identify the bones. However, the total number of collected bones (31) is incomparably less, to those previously found on Bykovsky Peninsula and Bol'shoy Lyakhovsky Island. Only one possibly fossil bone (fragment of reindeer tibia) was found on Samoylov Island. It was picked up on the beach below the section No. 2. During an excursion to Amerika-Khaya Island (Fig. map) a part of deer vertebral column was found, consisting of four connected vertebras. It was buried in peat in the upper part of the first terrace above the floodplain. The terrace is about 6 m high, the vertebral column was found at a depth of 2 m. The main bone collection was found on the Kurungnakh Island. The majority of bones belong to horses. Many bones were found in situ or in liquid mud of the bluff. A few bones (femur, tibia and metatarsale BKh-2002-O9, O17, O20) come from one horse individual. They fell down from the frozen wall related to a location between two peat horizons in progress of permafrost thawing. This place is located about 200 m upstream from section No. 2. A pelvis bone was observed thawing out the permafrost, but it was no chance to collect it. In the same layer near section No. 2 we noticed a big bone, probably femur of horse or bison, that could also not reached. Later, the bone immediately disappeared in liquid mud after melting out and falling down, and our attempts to find it again. In the same layer within several days two branches of one horse mandibula (Bkh-2002-O5, O13) were collected. Thus, the lower horizon of the Ice Complex unit of the Buor Khaya section contains rather abundant bone material. An interesting finding of a muskox metatarsal (BKh-O3), sticking out of frozen silt near an ice wedge was made in the upper part of the Buor Khaya section.