

## 4.7 Studies of coastal dynamics and sub sea permafrost

### 4.7.1 Preliminary results of sub-sea permafrost drilling in the near-shore zone (spring 2003)

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#### 4.7.1.1 Introduction and background

Studies of permafrost evolution in the coastal zone allow us to understand the on-shore – offshore permafrost system evolution more precisely. One of the main tasks of the new Laptev Sea System Project "Dynamics of Permafrost" is the evolution of the sub-sea permafrost within the near-shore zone of the shallow shelf. Practically, it is very difficult to realize this task without drilling. At the Cape Mamontov Klyk Area (the coast between Olenek and Anabar Rivers, Western Laptev Sea Coast) in the frame of the Russian-German Cooperation a relatively deep drilling by professional equipment and team is planned in the nearest future. In this connection a reconnaissance drilling was carried out in order to determine the position of the near-shore sub-sea permafrost table.

There are only a few drilling transects with shore face profiles in the Asian Arctic shelf seas. These transects have been made on sea ice in spring or on small drilling platforms. As usually, within the shallow Laptev shelf at the thermal abrasion coast the sub-sea permafrost table is found by drilling at depths between 5 and 60 metres. Unfortunately, deeper boreholes do not exist in the studied near-shore area. Sometimes, formations of new sub-sea permafrost were observed within bottom deposits of the shallow sea (Grigoriev N.F., 1966, Telepnev, 1981). Our previous studies of coastal permafrost degradation at Ice Complex coasts showed that the sub-sea permafrost table slowly submerges from shoreline to the deeper parts. An inclination of the permafrost table depends on various reasons, mainly on coastal erosion retreat rates, water temperature and salinity. Previous drilling transects in front of Muostakh Island and Bykovsky Peninsula (Central Laptev Sea coast) gave us some first information about permafrost degradation at quickly retreating coasts (Grigoriev, 1993). The average inclination of the sub-sea permafrost table is 0.007 and 0,013 at these sites. The corresponding average coastal erosion rate accounts 13 and 3 m/year (Grigoriev, Kunitsky, 2000) respectively. Some natural conditions in the area of Cape Mamontov Klyk are different from Central Laptev Sea offshore parameters. For example, water salinity at Cape Mamontov Klyk exceeds salinity at the Central Laptev Sea coast 3 to 5 times. This fact is very important for the understanding of rates of sub-sea permafrost degradation.

The drilling campaign started from Tiksi on April 11, 2003. During 13 days the went on the sea ice around the Lena Delta and than across the Oleneksky Bay. The thickness of sea ice was about 1.7-2.1 m. Basic equipment (Figure 4.7-1, 4.7-2) of the drilling field team consisted of a compact drilling machine UKB-12/25, two caterpillar tractors S-130, a cross-country vehicle GAZ-71, a

habitable mobile-home "balok" and two cargo sledges. During the way to the Cape Mamontov Klyk and back we had serious hardships with obstacles like sea ice cracks and hummocks but the technical equipment has stood the test.



**Figure 4.7-1:** Drilling process with the drilling machine UKB-12/25 on sea ice.



**Figure 4.7-2:** The caterpillar tractor S-130 and habitable mobile-home "balok" on the Laptev Sea ice.

#### 4.7.1.2 Methods and preliminary results

The drilling profile line started from the shoreline at the base of the snow-covered Ice Complex cliff (Figure 4.7-3). The profile consisted of 11 boreholes (1 to 32.5 meters deep). 10 seawater samples and 19 core samples for grain size, mineralogical and chemical analysis were collected. Because of distinctive cone-like drilling in liquefied bottom sediment it was impossible to collect a complete core. The near-bottom water temperature was measured during the drilling process.

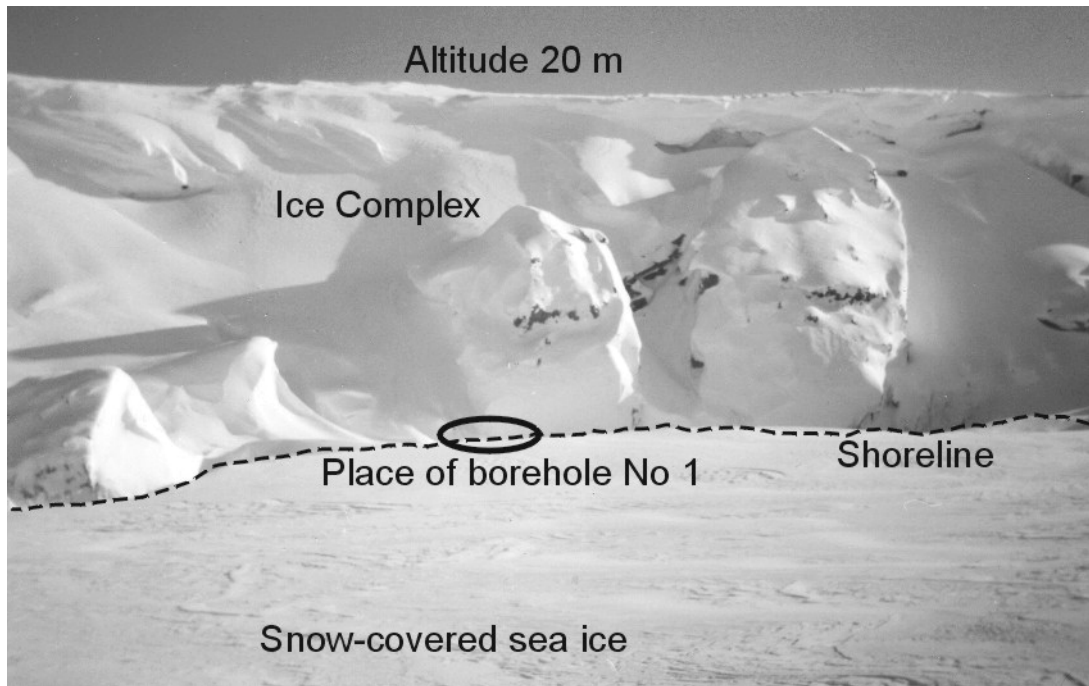
Average erosion retreat rate of the ice-rich coast at the beginning of the drilling profile is 5.8 m/year, taking into account that the average erosion rate for the whole adjoining coastal segment is about 3-4.5 m/year. These data were obtained during our previous studies (Grigoriev et al., 2000) and by comparison of up-to date measurements with remote sensing materials.

The base of Ice Complex deposits was found near the shore in a depth of 3 meters below sea level. The underlying sand deposits were discovered down to the depth of 30 meters below sea level. The deepest borehole reached 32.5 meters and showed some unexpected results (Figure 4). Despite of a high coastal erosion rate and very low water temperatures (from -1.3 to -2.1 °C) the inclination of the permafrost table in a distance of 1.3 km from the shore was very steep (0.015) and from 1.3 to 1.4 km – extremely steep (more than 0.3). This anomaly is probably explained by ancient thermokarst processes under sub aerial conditions. Estimation show that the average rate of permafrost table degradation is about 8 cm/year or slightly more at the studied transect.

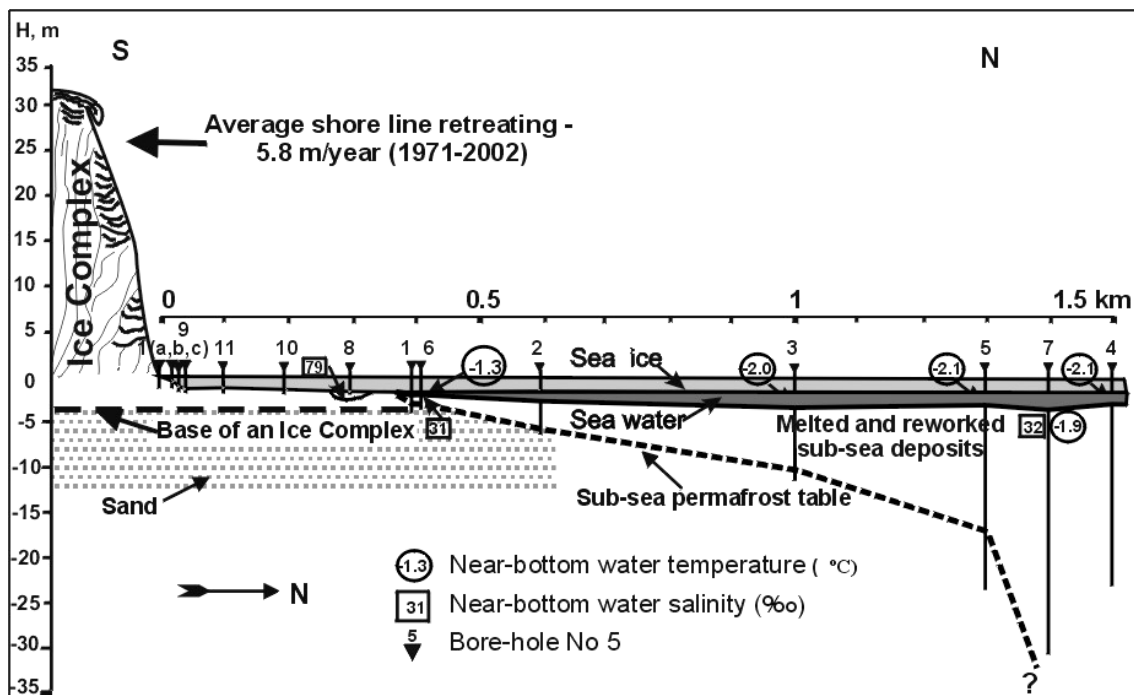
#### 4.7.1.3 Further investigations

In order to study the sub-sea permafrost evolution within the whole shore face profile near the Cape Mamontov Klyk a deeper drilling (up to 300 m depth) is planned in spring 2005. The main tasks of this drilling campaign are:

- To drill a longitudinal borehole profile by professional drilling machine;
- To determine the sub-sea permafrost table up to 10-15 km from the shore;
- To characterise the sediments;
- To analyse temperature and salinity distribution in the boreholes;
- To estimate rates of permafrost degradation depending on coastal erosion activity and other factors



**Figure 3:** The beginning of drilling profile at the shore (April, 2003).



**Figure 4:** Reconnoitring drilling profile of degraded continental offshore permafrost at the Cape Mammoth Tusk Area, Laptev Sea (April, 2003).

#### *Acknowledgements*

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