Late Quaternary palaeo-environmental history of Muostakh Island, Northern Siberia based on sedimentological and geocryological studies

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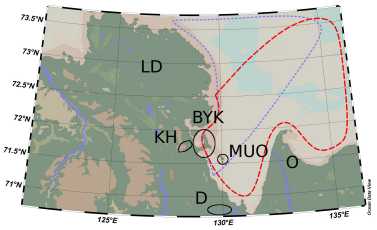
Introduction

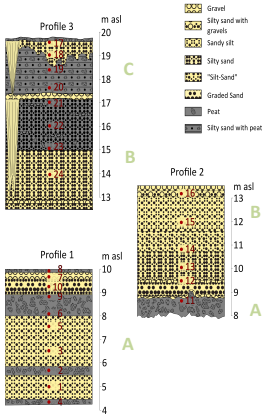
Muostakh Island (N 71°36'; E 129°57') is a spectacular site in the Siberian Arctic due to its very high coastal erosion rates of up to 20 m/year as well as substantial permafrost subsidence (Günther et al., 2015). The island extends about 7.5 km in N-S and ca. 500m E-W direction and has been connected to the mainland until a few thousand years ago.

Sediments and ground ice of the Yedoma type (so called Ice Complex; Schirrmeister et al., 2011) form up to 20 m high coastal cliffs on Muostakh Island. The main aim of this multi-proxy study is to cover the complete sedimentological and geocryological sequence for a detailed palaeoenvironmental interpretation of the island.



LD= Lena Delta; BYK= Bykovsky Peninsula; D= Darpi; KH= Khorogor;

Sedimentary sequence

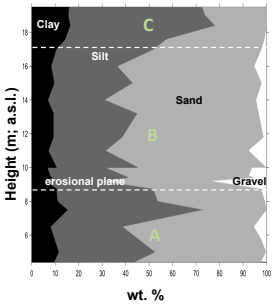


The sedimentary sequence is divided into three stratigraphic units A to C and consists of sediments of late Pleistocene to Holocene age.

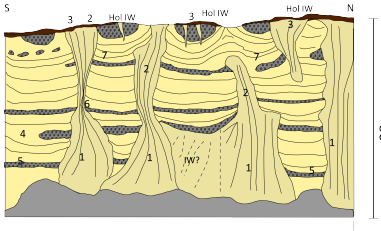
The lowermost **Unit A** (0-9 m a.s.l.) comprises of sandy silts alternating with thin peat layers. At the top, a 1 m thick peat layer is found in many sections on Muostakh. Ice wedges reach widths of up to 5 m.

At ca. 10 m a.s.l., a hiatus (41.6 kyr BP to ca. 19.7 kyr BP) is indicated by an erosional plane sharply intersecting ice wedges and sediments. **Unit B** is composed of 8-9 m of coarse-grained material, and indicative for fast and highly-energetic deposition, absent in many other Yedoma sites in the region.

The upper sedimentary **Unit C** reaches a maximum thickness of ca. 5 m and is laterally discontinuous. About 10 m wide peat patches of organic-rich and ice-rich Holocene sandy silts cover the underlying deposits. Peat patches are intersected by ice wedges of generally less than 1 m (up to 3 m) wide penetrating downwards into the older layers.

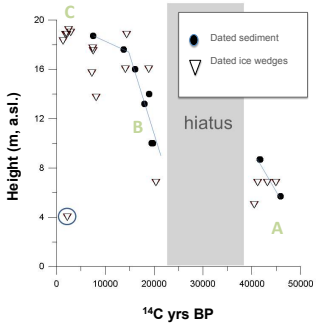


- Grain size analyses display coarse material, thus high transport energy for deposition of units A and B as well as the position of an erosional plane.

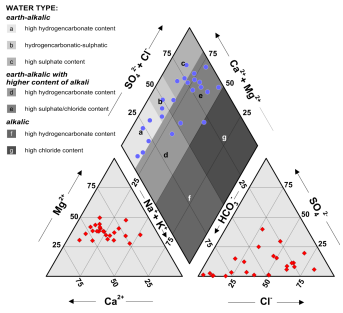


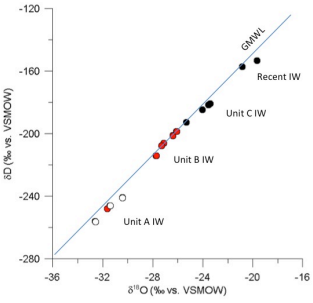
Results

Most results retrieved up to now of the Muostakh Island dataset include new Radiocarbon dating (upper left), sedimentology (above), hydrochemistry (lower left) heavy mineral (right) as well as stable isotope geochemistry data (middle column). A focus has been set on Unit B, which has not been studied in detail before.

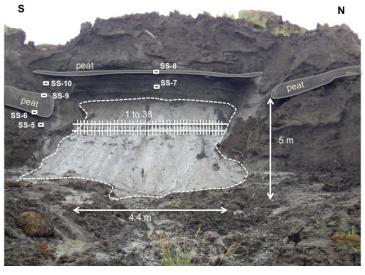


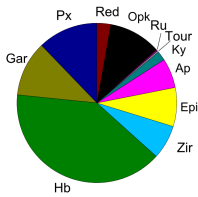
- The **age-height** diagram yields the ages of Units **A** (40-45 kyrs), a hiatus, **B** (20-13 kyrs) and **C** (<9 kyrs)
- Syngenetic ice-wedge growth is evident
- Unit B has the highest accumulation rate of more than 1 m per 1000 years
- **Hydrochemistry** is highly variable with predominant earth alkalic to alkalic composition

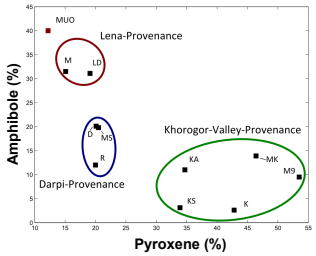




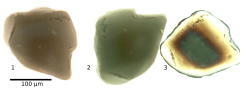
- Ground ice stable-isotope data indicate changing winter temperatures during ice-wedge formation on Muostakh Island: Unit A: coldest; Unit B: intermediate; Unit C: warmest.

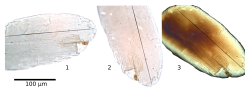






- The **heavy mineral assemblage** of the Muostakh Island section is dominated by Hornblende (below, left), Garnet and Pyroxene (below, right).
- There is only minor heavy mineral variation throughout the complete sedimentary profile (units A to C) and a single uniform Lena-type provenance is most likely.





Conclusions

→ Muostakh Island is a peculiar setting with impressive Ice Complex deposits covering the past 45 kyr. A hiatus of ca. 20 kyrs is evident from ca. 40 to 20 kyrs.

→ A subsequent high-energetic erosive event has delivered coarse-grained material at high accumulation rates to the site during and shortly after the LGM

→ Muostakh sediments of all three units display a single uniform heavy mineral composition, similar to the Lena River provenance.

→ Ground ice stable isotope geochemical analyses allow for differentiation of the winter temperatures during ice-wedge formation. There is no evidence for extremely cold winters shortly after LGM.

References
Günther F, et al. 2015. Observing Muostakh disappear: permafrost thaw subsidence and erosion of a ground-ice-rich island in response to arctic summer warming and sea ice reduction. The Cryosphere 9: 151-178. doi: 10.5194/tc-9-151-2015
Schirrmeister L, et al., 2011. Sedimentary characteristics and origin of the Late Pleistocene Ice Complex on north-east Siberian Arctic coastal lowlands and islands – A review. Quaternary International 241: 3-25. doi: 10.1016/j.quaint.2010.04.004