MINERAL ASSOCIATIONS OF LATE QUATERNARY PERMAFROST DEPOSITS - BOL'SHOY LYAKHOVSKY ISLAND COMPARED TO OTHER LOCATIONS IN NORTHERN SIBERIA

Schirrmeister, L.*, Wetterich, S.*, Schwamborn, G.**, Matthes, H.*, Grosse, G.*, Klimova, I.,*** Kunitsky, V.V.***, Siegert, C.*

* Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, 14473 Potsdam, Germany
** Eurasia Institute of Earth Sciences, Istanbul Technical University, Turkey
*** Melnikov Permafrost Institute SB RAS, Yakutsk, Russia

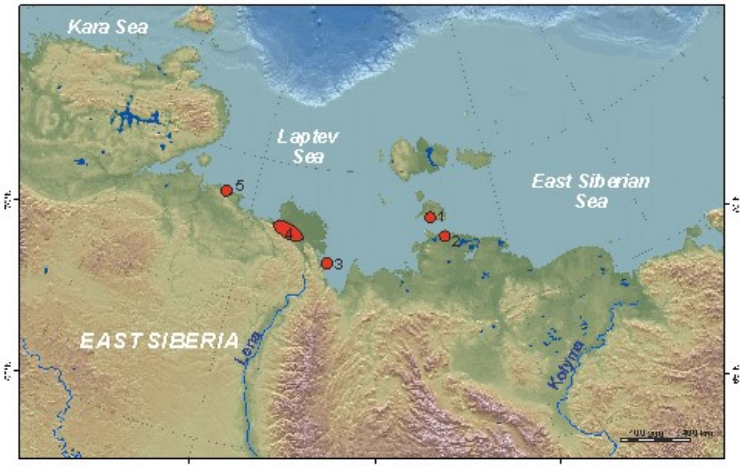

Fig 1. Study sites in the Lapev Sea region: 1-Bol'shoy Lyakhovsky Island (BL), 2 – Oyogos Yar coast (OY) , 3 – Bykovsky Peninsula (BYK), Western Lena Delta (WLD), 5 – Mamontov Klyk coast (MAK)

Background

As part of several joint Russian-German projects in the North East Siberian Arctic since 1998, numerous expeditions to the Laptev Sea region have been carried out. The participants were colleagues from the MPI Yakutsk, the MSU, the AARI, the Lena Delta Reserve Tiksi, the Hydrobase Tiksi, the AWI Potsdam, the University Hamburg and other institutions.

Methods

Several hundred analyses of heavy and light mineral composition on the 63 to 125 µm subfraction were carried out over many years at MPI Yakutsk by Olga A. Babii and Irina V. Klimova. Heavy minerals were separated using sodium metatungstate solution (density 2.89 g/cm^3). The mineralogical composition was analyzed under polarisation microscopes (POLAM L-213M) in slides using immersion liquids with n =1.54 and n =1.68 for the light and heavy fraction, respectively. For each fraction 300 to 400 grains per sample were counted.

Results

Heavy and light mineral associations of one of the best-dated permafrost sequences exposed at the southern coast of **Bol'shoy Lyakhovsky Island** (BL, Fig. 1) were analyzed. This record spans about 200 ka covering the Marine Isotope Stages (MIS) 7 to MIS 1. From these deposits, exposed from 0 to 35 m above sea level, heavy and light minerals of different stratigraphic units were studied.

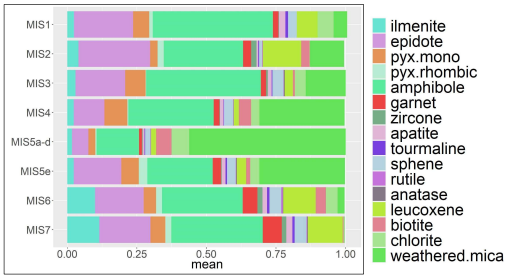

Fig. 2. Averages of heavy mineral associations of BL according to the stratigraphy

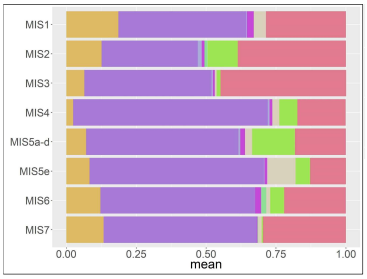

Fig. 3. Averages of light mineral associations of BL according to the stratigraphy

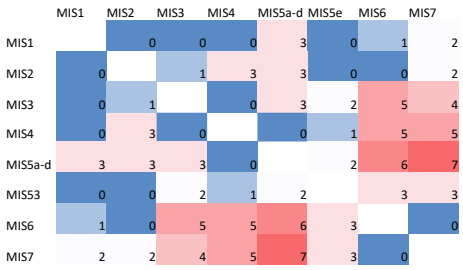

Fig. 4. Significance table of ANOVA variance analyzes of the heavy mineral association of BL

The mineral grains are subangular to slightly rounded. The heavy mineral association (Fig. 2) are dominated by amphibole, epidote, pyroxene, titanite, ilmenite, garnet, zircon, apatite, and rutile. Leucoxene is found in several samples as well as biotite, chlorite and weathered micas. The light mineral association (Fig. 3) are dominated by feldspar, quartz, and chlorites. Carbonates, muscovite, and broken mica are observed in some samples.

ANOVA reveals that MIS 7 (Yukagir Ice Complex) and MIS 6 (Zimov'e paleosol strata) differ distinctly from the other studied units. MIS 5e (interglacial Kazantsev thermokarst deposits), MIS 4 (Zyryan stadial floodplain, MIS 3 (interstadial Molotkov Yedoma Ice Complex deposits), MIS 2 (stadial Sartan Yedoma Ice Complex), and MIS 1 ((Holocene thermokarst deposits) are relatively similar to each other. Deposits of MIS 5a-d (i.e. Kuchchugui floodplain deposits, Buchchagy Ice Complex) are most different to all other units.

Characteristic unit associations of mineral composition of BL are assessed using variance analysis on the counted mineral grains. Statistically significant distinct mineral associations are found with ilmenite, garnet, zircon, tourmaline, titanite, and leucoxene in heavy and feldspar in light minerals. Ilmenite, garnet and leucoxene are the most relevant heavy and quartz, biotite and broken micas the most relevant light minerals for unit separation.

The BL heavy mineral associations were compared with **other study sites** (Fig. 1) on the Laptev Sea coast and in the Lena Delta (Fig. 5 to 8). Our findings suggest that each study site has its own heavy mineral association. However there are no significant differences within the individual study sites. This points to related formations of the units (e.g. thermokarst deposits formed within and partly from Ice Complex deposits). Each study site had its specific rock source.

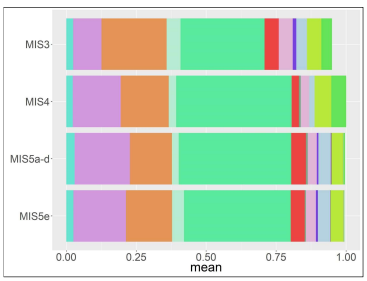

Fig. 5. Averages of heavy mineral associations of Oyogos Yar coast according to the stratigraphy

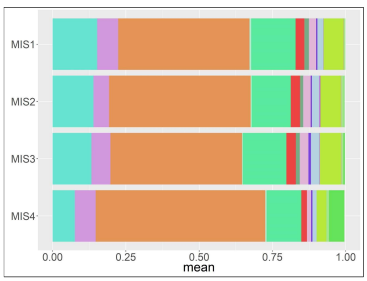

Fig. 6. Averages of heavy mineral associations of Bykovsky Peninsula (Siegert et al., 2002) according to the stratigraphy

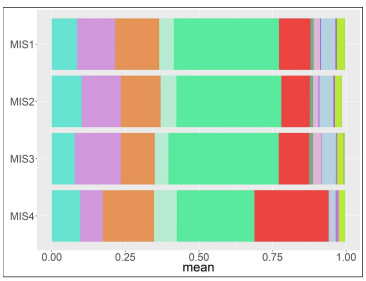

Fig. 7. Averages of heavy mineral associations of western Lena Delta (Schirrmeister et al. 2003, 2011) according to the stratigraphy

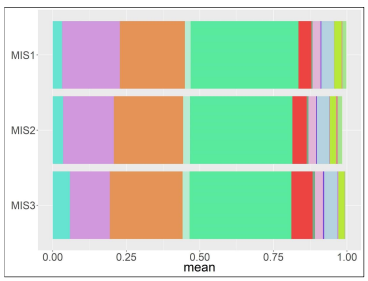

Fig. 8. Averages of heavy mineral associations of the Mamontov Klyk coast (Schirrmeister et al. 2008) according to the stratigraphy

Conclusions

- Heavy mineral associations of BL stratigraphic units indicate a stationary system back to MIS 5e. Deposits from MIS 6 and MIS 7 units statistically differ in their relative amounts of accessory minerals. MIS 5a-d is characterized by strong concentration of micas, which was connected to floodplain depositional dynamics.
- Similar modal inventories suggests recycling of heavy minerals in the stratigraphic columns.
- Weathered bedrock from nearby ridges and hills were the source material for the formation of Quaternary permafrost deposits.
- Heavy mineral associations differ significantly between the different studied areas in northern Yakutia.

References

Schirrmeister; L., Grosse, G. Schnelle; M., Fuchs; M., Krbetschek. M., Ulrich; M., Kunitsky, V., Grigoriev, M., Andreev, A.; Kienast, F., Meyer, H., Klimova, I., Babiy, O., Bobrov, A., Wetterich, S., Schwamborn, G. (2011). Late Quaternary paleoenvironmental records from the western Lena Delta, Arctic Siberia. Palaeogeography, Palaeoclimatology, Palaeoecology 299, 175–196, doi 10.1016/j.quascirev.2009.11.017.

Schirrmeister, L., Grosse, G., Kunitsky, V., Magens, D., Meyer, H., Dereviagin, A., Kuznetsova, T., Andreev, A., Babiy, O., Kienast, F., Grigoriev, M., Overduin, P.P., Preusser, F. (2008). Periglacial landscape evolution and environmental changes of Arctic lowland areas for the last 60,000 years (Western Laptev Sea coast, Cape Mamontov Klyk), Polar Research, 27(2), 249-272. doi:10.1111/j.1751-8369.2008.00067.x

Schirrmeister, L., Kunitsky, V. V., Grosse, G., Schwamborn, G., Andreev, A. A., Meyer, H., Kuznetsova, T., Bobrov, A., Oezen, D. (2003). Late Quaternary history of the accumulation plain north of the Chekanovsky Ridge (Lena Delta, Russia) - a multidisciplinary approach, Polar Geography, 27(4), 277-319. doi.org/10.1080/789610225.

Schirrmeister, L., Siegert, C., Kuznetsova, T., Kuzmina, S., Andreev, A.A., Kienast, F., Meyer, H., Bobrov, A.A. (2002). Paleoenvironmental and paleoclimatic records from permafrost deposits in the Arctic region of Northern Siberia, Quaternary International, 89, 97-118. doi.org/10.1016/S1040-6182(01)00083-0.

Siegert, C., Schirrmeister, L., Babiy, O. (2002). The sedimentological, mineralogical and geochemical composition of late Pleistocene deposits from the ice complex on the Bykovsky peninsula, northern Siberia, Polarforschung, 70, 2000, 3-11. doi:10.2312/polarforschung.70.3.