lasse.sander@awi.de

Characteristics of wave-built sedimentary archives in Buor Khaya Bay (71°N/130°E), Siberian Arctic, Russia

Lasse Sander[1], Rune Michaelis[1], Svenja Papenmeier[1], Sergey Pravkin[2], Karen H. Wiltshire[1]

[1]Alfred-Wegener-Institute (AWI), Helmholtz Centre for Polar and Marine Research, List/Sylt, Germany

[2]Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia

Prograded sequences of beach deposits preserve valuable paleoenvironmental information on the long-term variability of sea level, climate forcing and sediment supply: the main drivers of coastal evolution. Buor Khaya Bay, NE Siberian Arctic, is located at the transition between the Verkhoyansk mountain range and the southern Laptev Sea and is one of the few places along the Russian arctic coast, where wide beach-ridge systems exist. The area was visited during an expedition in August 2017 in order to obtain baseline information on the potential of five different coastal sedimentary systems (composed of barriers, spits, lagoons, and beach-ridge systems) for the reconstruction of Holocene relative sea level and past sea-ice extent.

The project is at an early stage of investigation and we present first insights into a new and promising area of investigation. Work will be continued in summer 2018.

Sequences of prograded beach deposits (so-called beach-ridge systems) are a wave-built coastal geomorphological feature of global occurrence. The deposits may preserve information on the environmental conditions during their formation and have been used as archives for the reconstruction of parameters such as relative sea-level, wave climate, extreme events, sediment supply or sea-ice extent (*e.g.* Funder *et al.*, 2011; Tamura, 2012; Sander *et al.*, 2016). Other coastal sedimentary systems (such as barriers and lagoons) may provide useful insights into the sedimentary record of processes determining shoreline change *e.g.* overwash frequency or extreme events. In general, only limited information on Holocene coastal evolution exists for the coast of arctic Siberia and all visited sites were previously unstudied.

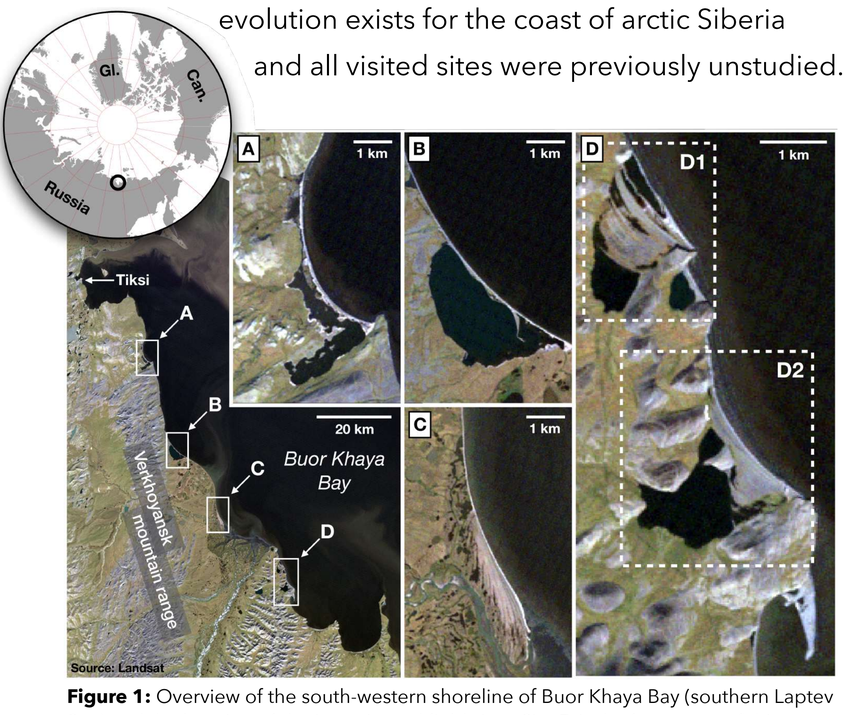

Figure 1: Overview of the south-western shoreline of Buor Khaya Bay (southern Laptev Sea) and the location of the investigated field sites. Site D is the focus area of this study.

The coastal geomorphology of the area is determined by the relief of the Verkhoyansk mountain range (*cf*. Figure 1). The bay is brackish, microtidal and ice-free for 3–4 months. Sites A and B are composed of slim and low-lying barriers that separate coastal lagoons from the open waters of Buor Khaya Bay. Site C is a wide barrier spit composed of wave-built deposits. Sites D1 and D2 comprise several sets of prograded beach ridges separating coastal lagoons from the open water of the bay and are surrounded by wave-cut cliffs in elongated morphological depressions. While sites A and B are subject to frequent overwash activity, sites C and D are characterised by the preservation of deposits and a steep modern storm berm. All sites are dominated by sand- to cobble-sized sediment. Apart from the sites described, most of the shoreline of south western Buor Khaya Bay is dominated by active bedrock cliffs.

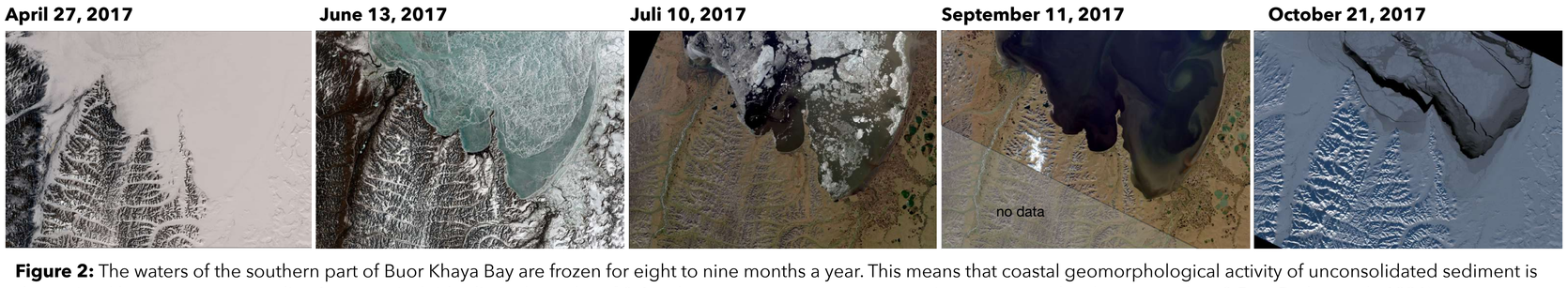

Figure 2: The waters of the southern part of Buor Khaya Bay are frozen for eight to nine months a year. This means that coastal geomorphological activity of unconsolidated sediment is determined by a strong seasonality. Astronomical tides lie in the order of 0.4 m, but summer storm surges may increase water levels to more than 2.5 m (Pavlov et al., 1996)

Methods

Satellite imagery, medium-resolution digital elevation models and archived topographical maps were used to provide information on the regional geographical context. At each field site, GPS-RTK elevation profiles were recorded perpendicular to the modern shoreline. Data on beach morphology and the surface properties of the elevated marine deposits (grain size, vegetation, debris) were collected in the field and supported by Kite-Aerial-Photography (KAP) surveys. Samples of partially buried driftwood were taken for AMS ^{14}C-dating (*cf.* Table 1).

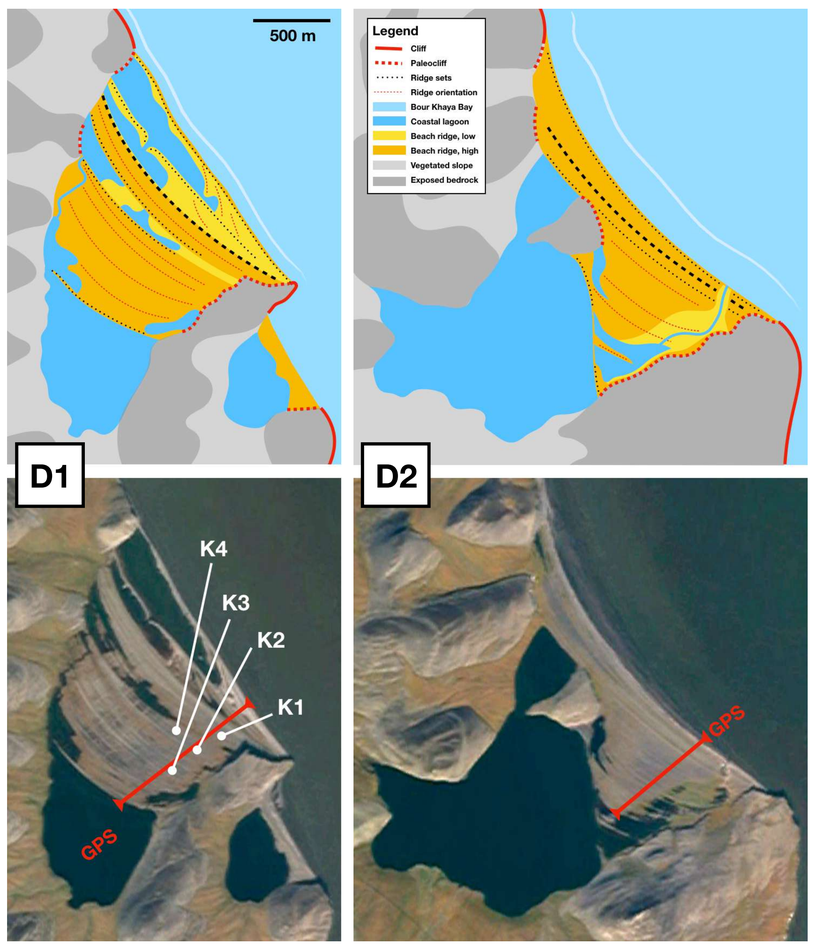

Figure 3: Field sites D1 and D2 are prograded beach-ridge systems located in topographic depressions within the denudated relief of the Verkhoyansk mountain range. Both sites are surrounded by marine (paleo-) cliffs and can be divided into different sets of ridges, separated by unconformities. Arrows indicate the locations of the ^{14}C samples (K1-4; cf. Table 1). Red line in the lower frames indicates the location of the shown GPS-RTK profiles (Fig. 4)

Table 1: Overview of ^{14}C samples from site D1 (dated at MICADAS Laboratory, Alfred-Wegener-Institute, Bremerhaven and calibrated using Calib 7.0.4 and the Intcal13 calibration curve)

Sample	Coordinate	Lab. code	Age (cal yr BP)
K1	71°1.728'N/130°11.991'E	1288	3380 - 3510
K2	71°1.670'N/130°11.656'E	1289	3720 - 3870
K3	71°1.593'N/130°11.402'E	1290	4430 - 4520
K4	71°1.738'N/130°11.466'E	1291	4230 - 4410

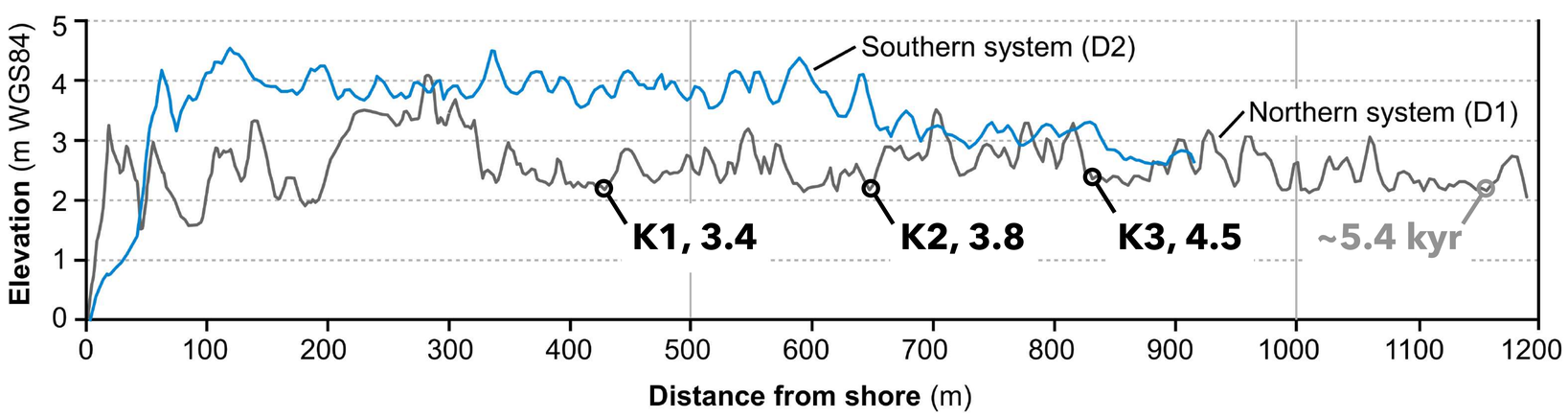

Figure 4: GPS-RTK profiles across site D1 (gray) and D2 (blue). The mean value of the calibrated ages established for site D1 are provided for orientation (cf. Table 1).

Acknowledgements: Field work was conducted as part of the expedition "LENA 2017". We would like to express our gratitude for the indispensable logistical support of Waldemar Schneider and Volkmar Aßmann (both AWI, Potsdam). The crew of RV "Nicole" is thanked for facilitating access to the field sites as well as for their hospitality during the field campaign. Torben Gentz and Gesine Mollenhauer (MICADAS Lab, AWI Bremerhaven) conducted the radiocarbon dating. Dagmar Lackschewitz (AWI Sylt) took close up images of the dated wood samples. Thanks for all the support!

Observations and inferences on coastal evolution

The modern shoreline at both beach-ridge sites (Fig. 3) is composed of a low gradient upper shoreface with longshore intertidal bars primarily composed of sands and gravels, and a steeply inclined beachface characterized by pebble- to cobble-sized material and the presence of ample amounts of debris (driftwood, anthropogenic debris; Fig. 5). The steep angle of the modern berm ridge (storm berm elevation: 3–4 m) and the presence of overtopped debris suggest the occurrence of increased water levels under high energy conditions. The fossil beach ridges have elevations of 2.5–4.5 m (*cf.* Fig. 4) with surfaces composed of pebble- to cobble-sized material. The elevation and composition of the beach deposits suggest a construction during (storm-)wave conditions.

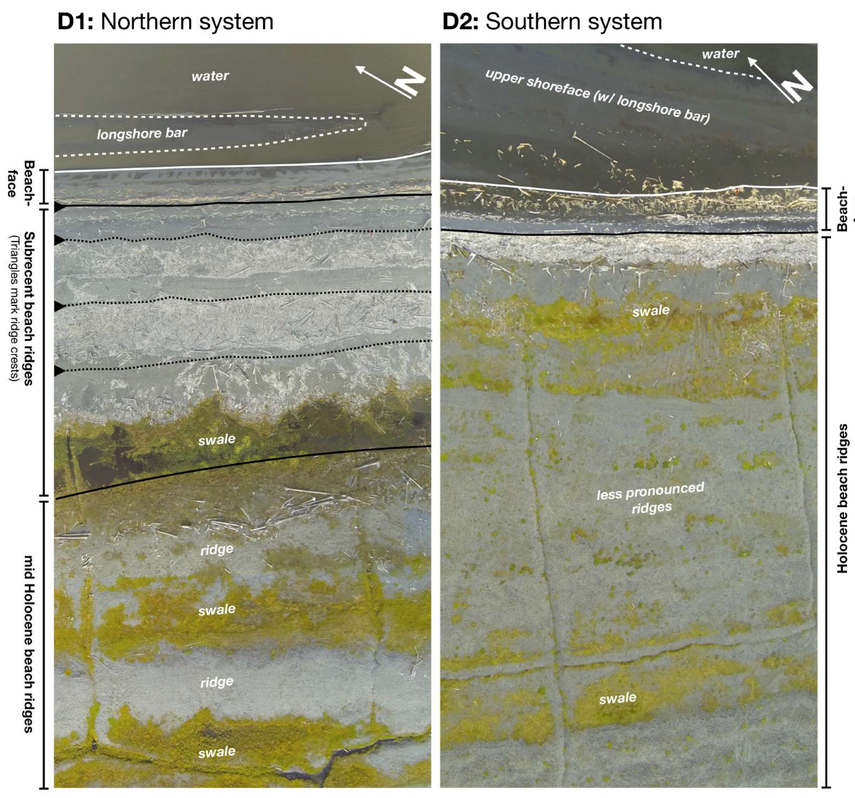

Figure 5: Aerial images of the proximal parts of both systems along the GPS-RTK profiles indicated in Fig. 3 and Fig. 4 (image height: ~ 350 m). The image of site D1 shows an unconformity between mid-Holocene deposits and younger beach ridges separated by a deep swale (*cf.* Fig. 4). The image of site D2 shows the modern beach and a denudated beach-ridge topography.

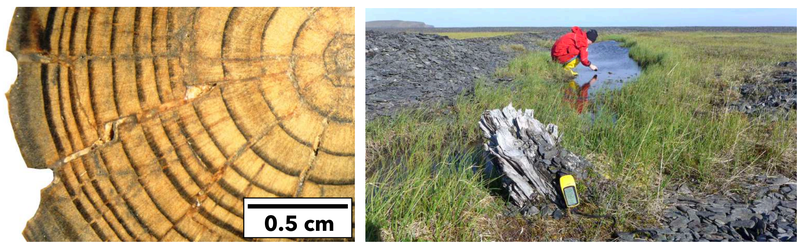

Figure 6: Buried driftwood was used for the establishment of age control

References

Funder S, Goosse H, Jepsen H, Kaas E, Kjær KH, Korsgaard NJ, Larsen NK, Linderson H, Lysså A, Möller P, Olsen J & Willerslev E (2011): A 10,000-Year Record of Arctic Ocean Sea-Ice Variability–View from the Beach. *Science* 333: 747- 750.

Pavlov VK, Timokhov LA, Basakov GA, Kulakov MY, Kurazhov VK, Pavlov PV, Pivovarov SV, Stanovoy VV (1996): Hydrometeorological Regime of the Kara, Laptev and East-Siberian Sea. Technical Memorandum APL-UW TM 1-96, AARI, St. Petersburg, Russia. 179 p.

Sander L, Hede MU, Fruergaard M, Nielsen L, Clemmensen LB, Kroon A, Johannessen PN, Nielsen LH & Pejrup M (2016): Coastal lagoons and beach ridges as complementary sedimentary archives for the reconstruction of Holocene relative sea–level changes. *Terra Nova* 28(1): 43-49.

Tamura T (2012): Beach ridges and prograded beach deposits as palaeoenvironment records. *Earth- Science Reviews* 114(3), 279-297.

HELMHOLTZ