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

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Prograded sequences of beach deposits preserve valuable paleoenvironmental information on the long-term variability of sea level, climate forcing and sediment supply driving centennial to millennial coastal evolution. Buor Khaya Bay, NE Siberian Arctic, is dominated by sand- to cobble-sized sediment. Apart from deposits and a steep modern storm berm. All sites are wave-cut cliffs in elongated morphological depressions. Sets of prograded beach ridges separating coastal lagoons from the open waters of the southern Laptev Sea. Site C is a wide barrier spit composed of a low gradient upper shoreface with gravels, and a steeply inclined beachface characterized by ample amounts of debris (driftwood, anthropogenic debris; Fig. 3). The steep angle of the modern berm ridge (storm berm elevation: 3–4 m) and the presence of overtopped gravelly 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. 3). 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. Swales are mostly vegetated and locally water-logged. The surrounding headlands show clear indication of wave erosion (in the form of active and paleocliffs) and thick layers of regolith cover the slopes. The minerogenic beach deposits are composed of flat subangular to rounded shales. These are probably of local origin, given their high degree of similarity (color, lithology) with the weathering products from adjacent bedrock cliffs. No aeolian deposits were observed. The elevation and composition of the beach deposits suggest a construction during (storm-)wave conditions. Both systems can be divided into distinct sets of ridges, suggesting (1) continuous progradation under conditions of high sediment availability over mid-Holocene time scales, and (2) unconformities evidencing periods of increase in allogenic perturbation or reduced sediment supply.

Methods
All field sites were accessed by boat. At each site, GPS-RTK elevation profiles were recorded in a cross-ridge direction, 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. Age control (for system D1) was established using the 14C-dating of buried drift wood (dated at MICADAS Laboratory, Alfred-Wegener-Institute, Bremerhaven; cf. Table 1). Preparation of the campaign and the interpretation of field data are supported by Landsat satellite imagery, medium-resolution digital elevation models and archived topographical maps.

Conclusions and outlook
This study has for the first time established the elevation and Holocene age of two prograded beach-ridge systems in NE Siberia. The arrangement of landforms suggest fluctuations in the parameters determining their long-term evolution, specifically sediment supply, relative sea-level and the direction of wave approach. In the next field season, we will continue our work on site D in order to complement the dataset with additional age control, georadar profiles and photogrammetric survey data. The aim is to gain more detailed insight into the past and present processes that influence the formation and preservation of wave-built deposits in the Arctic settings of northern Siberia as well as to unravel the indication they contain on the climate and sea-level history of the southern Laptev Sea.

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References

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

Figure 2: Field sites D1 and D2 are prograded beach-ridge systems located in topographic depressions within the denuded relief of the Verkhoyansk mountain range. Both sites are surrounded by marine (paleo) cliffs ( Cf. Figure 1). You can be divided in different sets of ridges by by onformations (dashed white lines). Arrows indicate the location of the HC samples (K1-K4; cf. Table 1). Red line indicates the location of the shown GPS-RTK profiles (Fig. 4).

Figure 3: Aerial images of the proximal parts of both systems along the GPS-RTK profiles indicated in Fig. 2 and Fig. 4 (image height: ~ 350 m). The image of site D1 shows a discontinuity between mid-Holocene deposits and younger beach ridges separated by a deep swale (cf. Fig. 4). The presence of large amounts of debris suggests subsequent perturbation of the younger and lower-lying ridges. The image of site D2 shows the modern beach and a denuded beach-ridge topography. This setting suggests a hiatus in progradation likely caused by a limitation of space due to the consecutive still of the embayment.

Table 1: Overview of HC samples from site D1

Sample | Coordinate | Lab. code | Age (yr)
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K1 | 71°11.78°/130°11.99° | 1286±22 | 3234±177
K2 | 71°16.67°/130°11.65° | 1289±23 | 3540±187
K3 | 71°15.93°/130°11.40° | 1290±23 | 4028±187
K4 | 71°13.78°/130°11.46° | 1291±23 | 3826±177

Figure 4: GPS-RTK profiles across site D1 and D2.

Figure 5: Overview of the south-western coastline of Buor Khaya Bay (Southern Laptev Sea) and the location of the investigated field sites. Site D is the focus area of this study.

Figure 6: Progradation and sea-level change in Holocene progradation cases from the Norwegian Sea. Earth-Science Reviews 96(1-3): 79-97.