

Ground ice as a factor of coastal dynamics at south-western part of Kara Sea

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Abstract

For three key sections of the Kara Sea coast (Ural and Yamal coasts of Baydaratskaya Bay, Kharasavey Cape) the spatial variability of the of ground ice distribution (changes in ice content, massive ice occurrence) is traced. At the local level ground ice leads to high retreat rates compared to adjacent coastal segments. However, it is often difficult to distinguish between the contribution of ground ice and other parameters of coastal structure (such as fine-grained ice rich bluffs) to the resulting retreat rate. The maximum retreat rates of ice-rich coasts were observed in years with higher sum of positive air temperatures.

Keywords: coastal erosion; Kara Sea; ground ice; wedge ice; massive ground ice.

Introduction

The coasts of the southwestern part of the Kara Sea are composed of permafrost sediments (except for the rocky coasts of Yugorskiy Peninsula) and retreat with average annual rate 0.5 to 2 m per year (Vasiliev *et al.*, 2006; Lantuit *et al.*, 2012; Kritsuk *et al.*, 2014; Ogorodov *et al.*, 2016). As in other Arctic regions, retreat rates of permafrost coasts vary both spatially and temporally.

Ground ice as a factor of coastal retreat

Different types of ground ice are spread very uneven in the cryolithozone; the spatial distribution of ground ice is determined by the history of the development of the region's natural environment, including the conditions for the formation of permafrost. The contribution of ground ice to the rate of coastal erosion is also uneven and is determined not only by the total ice content but primarily by the structure of the coast. Researchers attempted to establish a correlation directly between the rates of retreat and the ice content of the coastal bluffs, it was assumed that the presence of ground ice would lead to an increase in the rates of retreat. However, in studies devoted to a particular region or to the Arctic shores as a whole (Héquette & Barnes, 1990, Lantuit *et al.*, 2008), the correlation between ground ice content and the retreat rates was at best weak. The reason is that the studies analyzed the retreat rates of the coasts, which are extremely heterogeneous in terms of structure and hydrometeorological conditions. A wide range of factors

contributes to coastal dynamics and the influence of an individual factor can only be traced locally (Konopczak *et al.*, 2014).

Key Sites at South-Western Coast of the Kara Sea

At three key sites (Fig.1) coastal dynamics have been investigated by researchers of Laboratory of geoecology on the North since the 1980s, including both field work and remote methods (analysis of aerial and satellite multitemporal imagery).

Kharasavey Cape, Western Yamal Peninsula

Cliffs 7–12 m in height are composed of permafrost deposits and retreat at an average annual rate of 1.1 m per year over a 52-year period (Belova *et al.*, 2017). The highest mean annual retreat rates (>2 m per year) are typical for coasts composed by very ice-rich fine silty clays; their cryogenic structure being the main factor of such fast retreat. In 2006–2016, average retreat rates increased to 1.2 m/year compared with the 1.0 m/year rate in 1964–2006, primarily due to the accelerated erosion rates of icy silty clays in the coastal cliffs. The impact of hydrometeorological forcing on Kharasavey coastal area increased in the late XX–early XXI centuries, causing faster coastal retreat.

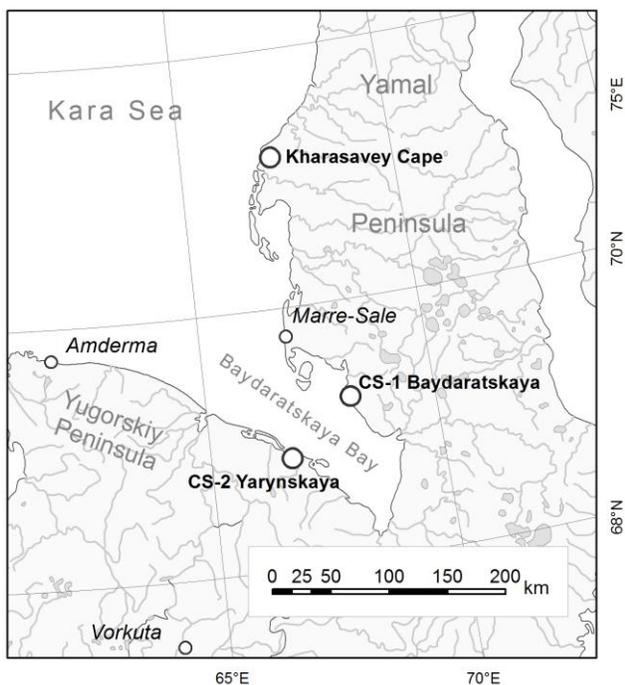


Figure 1. Research area.

Ural coast of Baydaratskaya Bay, Oyuyacha River mouth (CS-2 Yarynskaya)

The highest observed retreat rates were observed at laida (modern marine terrace up to 2 m height) with dense network of ice wedges. Along with ground ice, the factor of bluff height promotes accelerated coastal erosion. The segments of sandy bluffs 12-27 m height retreat with highest rates at sections with massive ice beds exposures (mean annual rate 2 m per year) due to thermocirques formation.

Yamal coast of Baydaratskaya Bay, Yarayacha River mouth (CS-1 Baydaratskaya)

Key site is characterized by low retreat rates (0.3-0.7 m per year) first of all due to the low ice content of sandy bluffs up to 30 m height. Local increase in retreat rates is due to anthropogenic impact.

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