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Meso-Cenozoic exhumation and relevant isostatic process: The Barents and Kara shelves

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ABSTRACT

Fennoscandia and Arctic shelves are known to have experienced several periods of Meso-Cenozoic uplift and erosion, but their magnitude and timing are still debated. The aim of our study is to estimate erosion volumes and distinguish between different erosional episodes, including glacial and pre-glacial ones. Our estimation approach is based on a combination of geological-geomorphological analysis, computer simulations of different erosion processes in time and space, mass-balance, burial control, and other methods Isostatic modelling is an obligatory component in the geomorphological reconstructions, since the erosion and subsequent isostatic uplift change the inclinations of various surfaces. Isostatic modelling is especially of significant importance in cases of poor or lacking age control.

We find that the role of Neogene erosion might previously have been strongly exaggerated in some areas. Intensive Triassic-Jurassic deformations mark exhumation of positive structures (i.e. Novaya Zemlya, Pay-Khoy, Fedynsky). Novaya Zemlya – Pay-Khoy – Polar Ural belt was likely strongly exhumed during Neocomian (Berriasian). Upper Cretaceous erosion was noticeable in some structural zones, and strong Rupelian erosion is evident in Cenozoic. Changes of depositional provinces complicated the pattern, especially in Eocene.

The role of climatic changes with global cooling could be discussed for Oligocene. Neogene erosion, with final glacial substages completed the erosional history, creating several prominent troughs and basins.

We present a high-resolution model of Quaternary glacial and fluvioglacal erosion. Many landforms in the area were modified by glacial and periglacial processes, in particular by variable glacial erosion due to lithological, structural and topographic diversity. Glacial erosion of relative highs was often of minor importance, but other erosional agents could be active locally. We suggest a scenario of typical ice sheet development in the Barents Region, for the use in erosion computations. Radial glacial erosion pattern and significant basal ice velocities seem to be expected at the beginning of the early ice-age stage, resulting in widening of pre-glacial drainage elements. Pre-glacial lowlands and river pattern could provoke early stage onset of topographic ice-streams, especially in permafrost condition.

Major ice streams were predefined by geological structures and tectonics.

Different values of the elastic properties of the lithosphere dramatically impact isostatic movements and influence mass-balance computations, landscape features and delineation of watersheds.

1. Introduction

The Barents – Kara Sea region is characterized as strongly impacted by Cenozoic uplift and erosion. A sometimes used term connected to uplifted, eroded sedimentary basins where removal of overburden has taken place is 'exhumation'. This is a somewhat loosely and descriptive term, which might be defined as 'the unroofing history of a rock, as caused by tectonic and/or surficial processes' (Ring et al., 1999). It is seldom characterized as a measure, unlike erosion, which is often described in terms of loss of thickness mass or volume (Doré et al., 2002a). Exhumed basins are frequently evaluated in the same way as 'normal' subsiding basins, leading to errors and unrealistic expectations for petroleum exploration (Doré et al., 2002b). Exhumation leads to cooling and pressure decrease, and these factors add a degree of difficulty to petroleum exploration. Some key implications that exhumation can have on petroleum systems are summarized by et al. (2002a,b); and Fjeldskaar and Amantov (2017a): 1) sealing horizons are removed and/or their effectiveness is severely reduced; 2) faults are often reactivated

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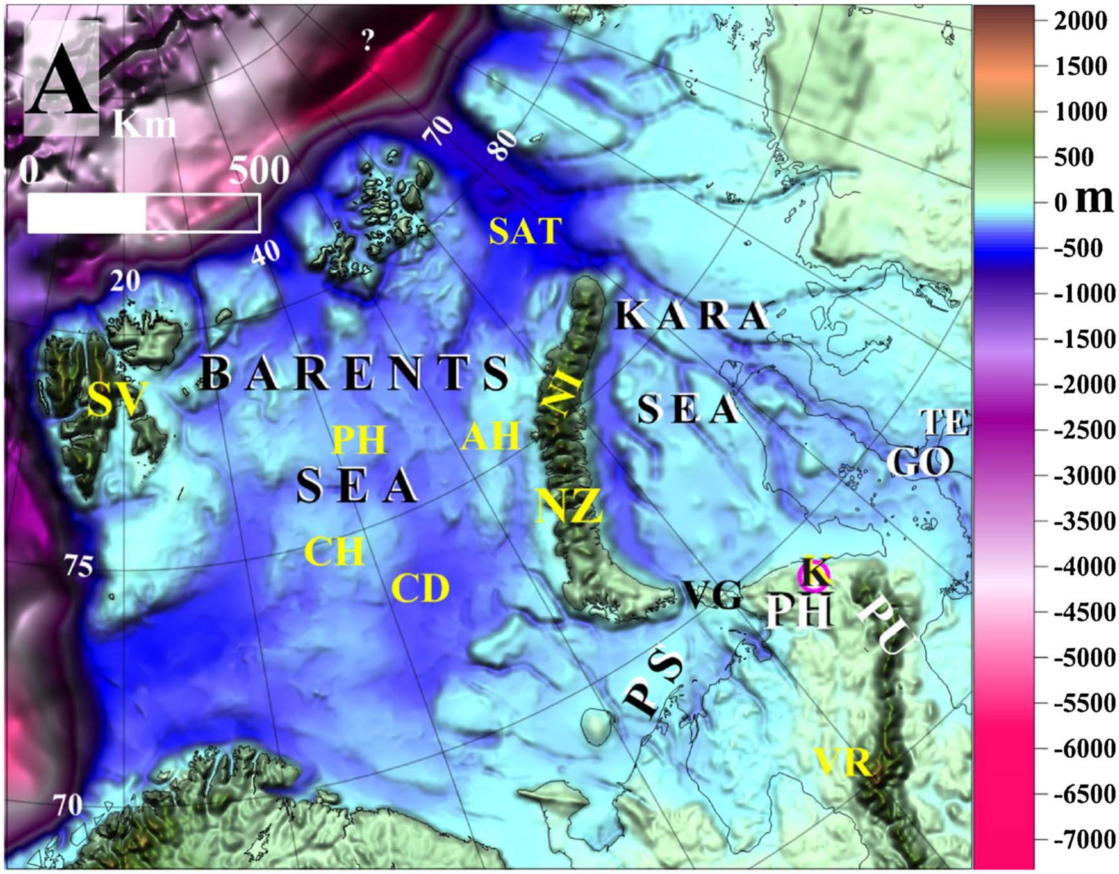

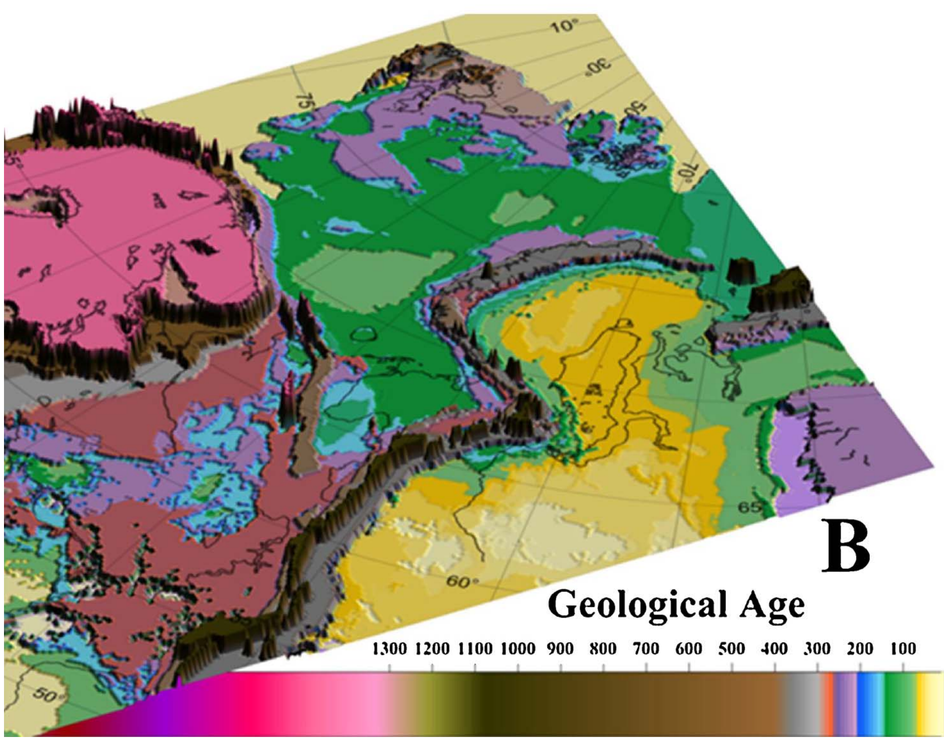

Fig. 1. A − simplified bedrock topography of the region (Base Pleistocene). The locations used in text: SV-Svalbard, PH-Perseus High, CH-Central Barents High, CD-Central Barents Deep, AH-Admiralty High, SAT-St. Anna Trough, NZ-Novaya Zemlya, NI-Northern Island of Novaya Zemlya, PS-Pechora Sea, VG- Vaygach Island, PH-Pay-Khoy, K-Kara crater, PU-Polar Ural, VR-Vorgavozh basin, GO-Gulf of Ob, TE- Taz Estuary. B − Geological control grid (average isotopic age in Myr), compiled using published geological maps (Harrison et al., 2008; Petrov et al., 2008). Older "uplifted" domains commonly (but not necessary) indicate larger "net" erosion, and vice versa.