THE LATE QUATERNARY HISTORY OF THE PECHORA SEA

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Abstract

More reliable reconstructions of the Late Quaternary glacial history of the Pechora Sea have been carried out due to new radiocarbon datings. The bulk of evidence favors the view that complete deglaciation of the Pechora Sea occurred in the middle Valdai epoch, about 35-40 ka. After a short interstadial period with normal marine conditions, sea-level fall gave rise to establishment of continental environments. In the late Valdai, the Novaya Zemlya ice sheet occupied only the northernmost Pechora Sea and did not reach the Pechora Lowland. In the course of the subsequent Holocene transgression, the shelf was abraded. Modern lithodynamic conditions in the Pechora Sea determine accumulation of sandy-silty deposits.

Introduction

Though the Quaternary history of the North American and Eurasian arctic margins has been adequately studied the extent of the Pleistocene ice sheets in the Barents Sea area, and, in particular, in the Pechora Sea, is still a point open to question. In this area, the Quaternary deposits form a single more than 1000 m thick terrigenous formation unconformably overlying the Paleozoic and Mesozoic rocks. One group of scientists (Gritsenko and Krapivner, 1989; Danilov, 1982) considers these deposits to have been accumulated under marine conditions during the whole Pleistocene and even Neogene. Another group of scientists is of the opinion that this formation includes thick glacial beds, and the youngest preserved glacial layers are of the Valdai age (Gataullin et al., 1993; Polyak et al., 2000).

Material and discussion

As a result of analysis of the sediment core data (Fig. 1), deposited and published materials, and new radiocarbon datings (Table 1), it became possible to reconstruct the evolutionary history of this region on a higher scientific level.

The Quaternary deposits of the Pechora Sea shelf were formed under the influence of global sea-level oscillations and repeated changes in environmental conditions from marine to continental ones. The latter were distinguished by development of thick ice sheets. As a result, shelf sediment sequence represents an extremely complicated intercalation of Pleistocene moraines and interglacial beds overlain by Holocene marine sediments. Age estimation of the morainic beds is rather difficult, but the presence of ice sheets on the Pechora Sea shelf during the early-middle Pleistocene is beyond question, because several cores were drilled into morainic beds overlain by the Mikulino marine deposits (Tarasov et al., 2000).

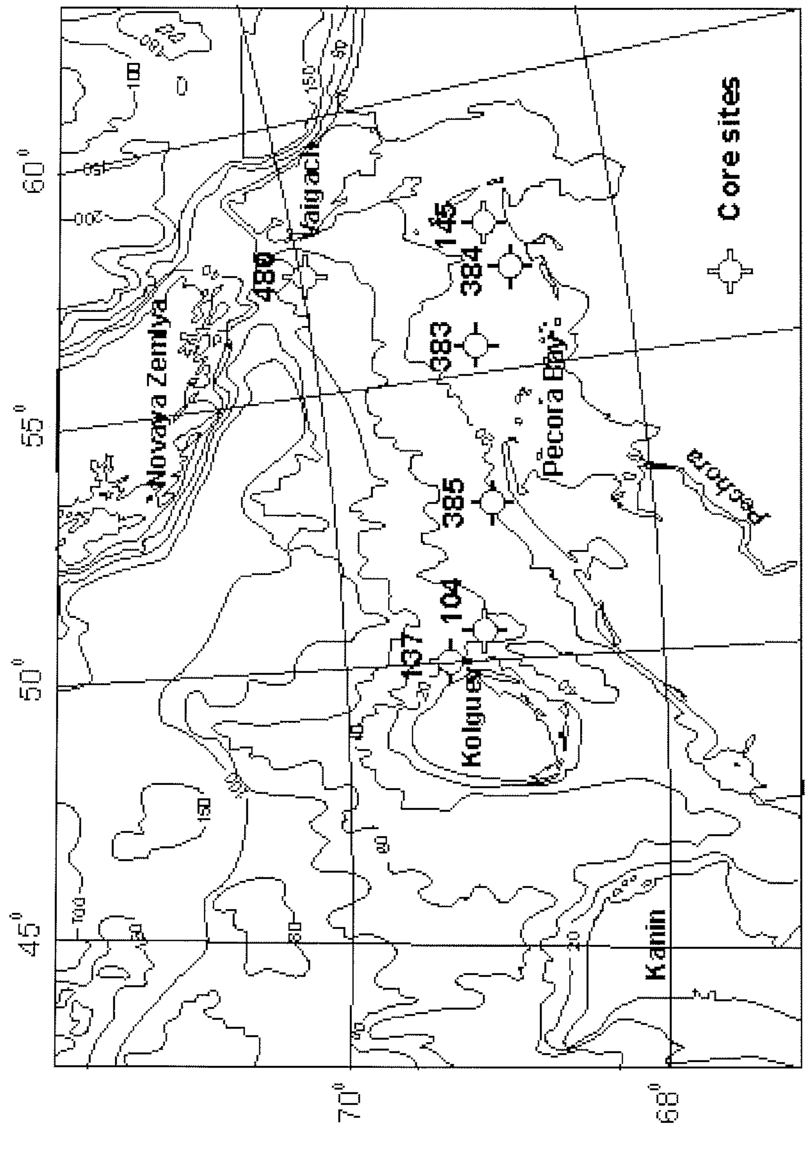

Fig. 1. Location map of the studied cores

During the Mikulino epoch, North Atlantic water flowed into the Barents and Pechora seas considerably farther eastward than at present, as documented by composition of foraminifers in the Mikulino horizon in core 145 recovered in the Varandei area, central part of the Medynskii arch (Figs. 2, 3).

Table 1. Accelerator mass spectrometer ^{14}C dates

Lab. no.	Core no.	Depth in core (m)	Material	Mass (mg)	Uncorrected age (yrs. B.P.)
KIA 16840	137	1.4-1.5	*Montacuta maltzani*		5360±30
KIA 16841	137	9.4-9.5	*Montacuta maltzani*		5390±30
KIA 16843	137	35.0-35.1	shell detritus		>52900
KIA 16844	137	42.0-42.1	shell detritus		>52900
KIA 16845	480	2.0	plant detritus	0.5	22390±420/-400
KIA 16846	480	19.5	plant detritus	2.8	27560±210
KIA 16847	480	41.8	plant detritus	1.4	26110±260
KIA 16848	480	73.2	plant detritus	2.2	26170+210/-200
KIA 16849	480	82.4	plant detritus	2.9	28460+220/-210

The foraminiferal assemblage, found in the dark grey clays with rare pebbles and interlayers of fine well-sorted sand, does not have any analogs in the modern fauna of the Pechora Sea. High species diversity, considerable portion of boreal species, and absence of any traces of dissolution on foraminiferal tests provide evidence for normal marine salinity and hydrochemical regime of bottom and pore waters, which favored preservation and burial of tests. The palynological association dominated by arboreal pollen indicates interglacial conditions (Sharapova, 1996).

The early Valdai cooling gave rise to thick ice sheets, which covered the Pechora Sea and Pechora Lowland. Glacial streams reworked a considerable portion of the marine Mikulino sediments. The early Valdai deposits are represented by dense dark grey loams with coarse-grained material and single faunistic remains of definitely allochthonous origin. No spores and pollen of the Quaternary age were reported from these beds.

Revision of the drill and seismoacoustic data with the help of modern chronostratigraphic methods (Polyak et al., 2000) has shown that the Pleistocene loams of the southeastern Pechora Sea are overlain by indistinctly laminated dark grey silt. The lower 10 m of this silt are enriched in foraminifers, molluscs, and ostracods indicative of marine interglacial conditions. Palynological spectra include a considerable portion of arboreal pollen. The sediments yield radiocarbon age estimations of 39-35 ka. It can be concluded, therefore, that the Pechora shelf became considerably deglaciated in the middle Valdai epoch.

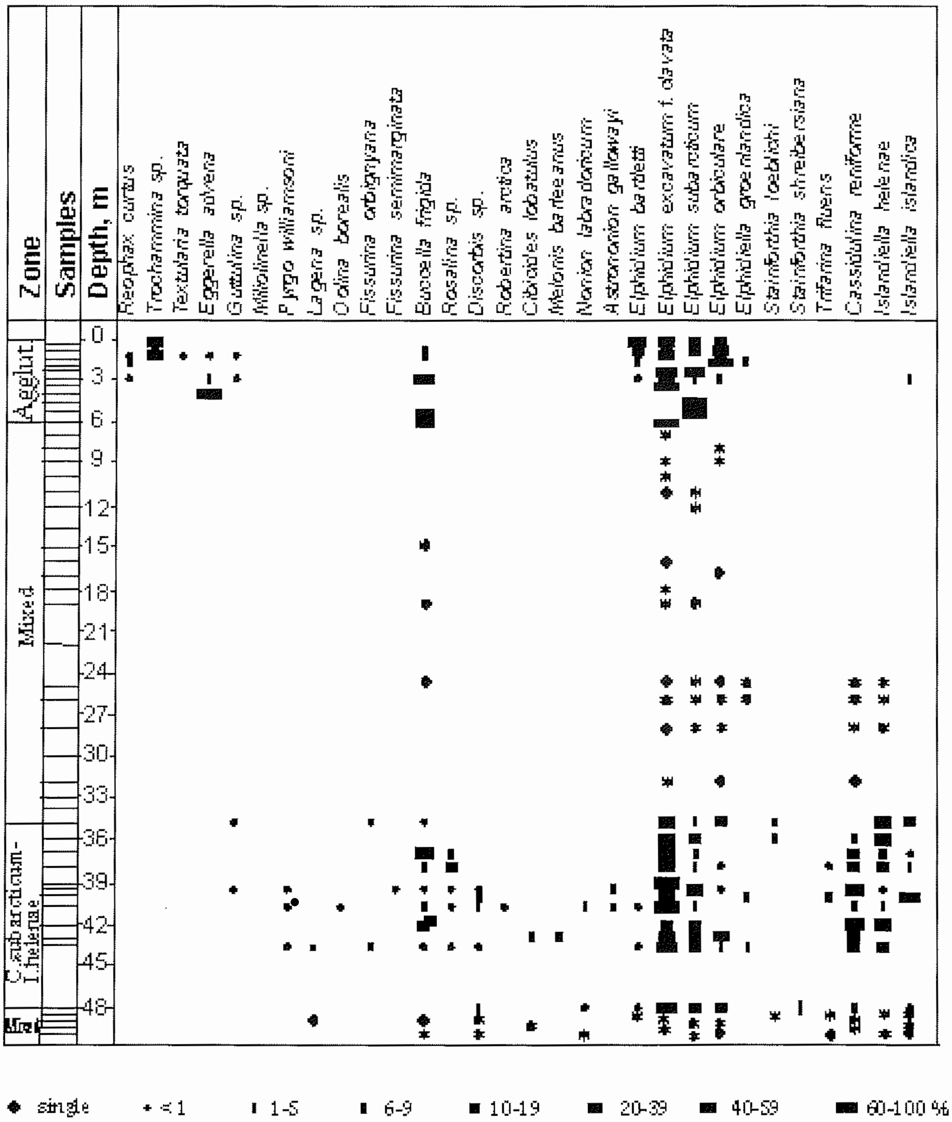

Fig. 2. Relative abundance (%) of ***Foraminifera*** species in core 145

These data are in accordance with radiocarbon and thermoluminescence datings of the post-glacial deposits on the Pechora Lowland and Yamal Peninsula (Mangerud et al., 1999; Forman et al., 1999). Micropaleontological investigations of the Pleistocene sections on the Kola Peninsula (Gudina and Evzerov, 1973) have provided evidence for a vast transgression during the Karga epoch (40-35 and

30.7-24.1 ka). The Karga transgressive waters flooded coastal lowlands and estuarine parts of the rivers. However, the Karga basin was considerably smaller in size than the Mikulino and, probably, the modern basins. We assume that the southeastern shelf was exposed. In core 145 located farther south than the cores studied by Polyak et al. (2000), marine layers enriched in fossils have not been found. Marine faunistic assemblages of the Karga and Mikulino beds are different. Paleofaunistic assemblages of the Karga age are composed of arctic species that inhabited a cold modern-like sea basin.

Due to the subsequent sea-level fall, the short interstadial period with normal marine conditions was replaced by the period with continental environments. In the southern part of the sea, the Pleistocene loams are overlain by grey, regularly laminated, silts practically devoid of faunistic remains. Spore and pollen spectra of these deposits are dominated by herbaceous pollen, mainly wormwood (*Artemisia*). Absence of microfauna and increasing percentage of herbs mark the transition to shallow-water marine, prodeltaic conditions due to sea-level fall and close location to coastline. A considerable part of the Pechora Sea was exposed and represented coastal marine, alluvial-marine, and alluvial-lacustrine plains subjected to active cryogenic processes and permafrost formation (Avenarius and Dunaev, 1999). In the northern Pechora Sea, near the Karskie Vorota Strait, a thick clayey sequence was accumulated (Fig. 4). The studied core 480 displays a 100-m-thick series of dark grey plastic-frozen clayey sediments without any visible lithological boundaries (Fig. 4). Temperature of the sediments does not show any gradient and equals –1.0 to -1.5°C. Ice content is the highest in the upper part of the core (up to 60%) and decreases downcore (down to 5-10%). Ice schlieren are usually angular and reach 3 cm in size. Ice is clean and transparent without any visible inclusions. Thin clay interlayers (up to 30 cm thick) with preserved net-like cryostructure occur throughout the whole core section. Micropaleontological analysis of the sediments revealed abundant plant debris and single microscleres of tetractinellid sponges. Radiocarbon age estimations (Table 1) evidence high sedimentation rates. The age reversal could be a result of strong dislocation due to sediment freezing. Thus, during the late Valdai epoch, the Novaya Zemlya ice sheet occupied only the northernmost Pechora Sea and did not reach the Pechora Lowland.

Later, in the course of the Holocene transgression, the shelf underwent intensive abrasion by the advancing sea. Holocene sediments are present all over the Pechora Sea. They overlie the eroded surface of the Pleistocene beds, and the contact is often marked by a layer of pebbles and gravel. The thickness of Holocene sediments varies from several meters to 50 m (Skorobogat'ko, 1992; Polyak et al., 2000). Increasing thickness is observed in neotectonic depressions. Core 104 recovered near the eastern coast of Kolguev Island (Fig. 1), reveals a 44.2-m-thick Holocene sequence represented by sands underlain by silts and clays. Similar deposits were recorded in the core 137, recovered nearly (Fig. 5), with a thick sandy-clayey unit that has been accumulated extremely rapidly. The radiocarbon age of the *Montacuta maltzani* bivalve shells is 5390±30 years (KIA-16841) for the sample from 9.4-9.5 m interval, and 5360±30 years (KIA-16840) for the sample from 1.4-1.5 m interval. Therefore, the sedimentation rates in this part of the shelf during the middle Holocene were avalanche-like.

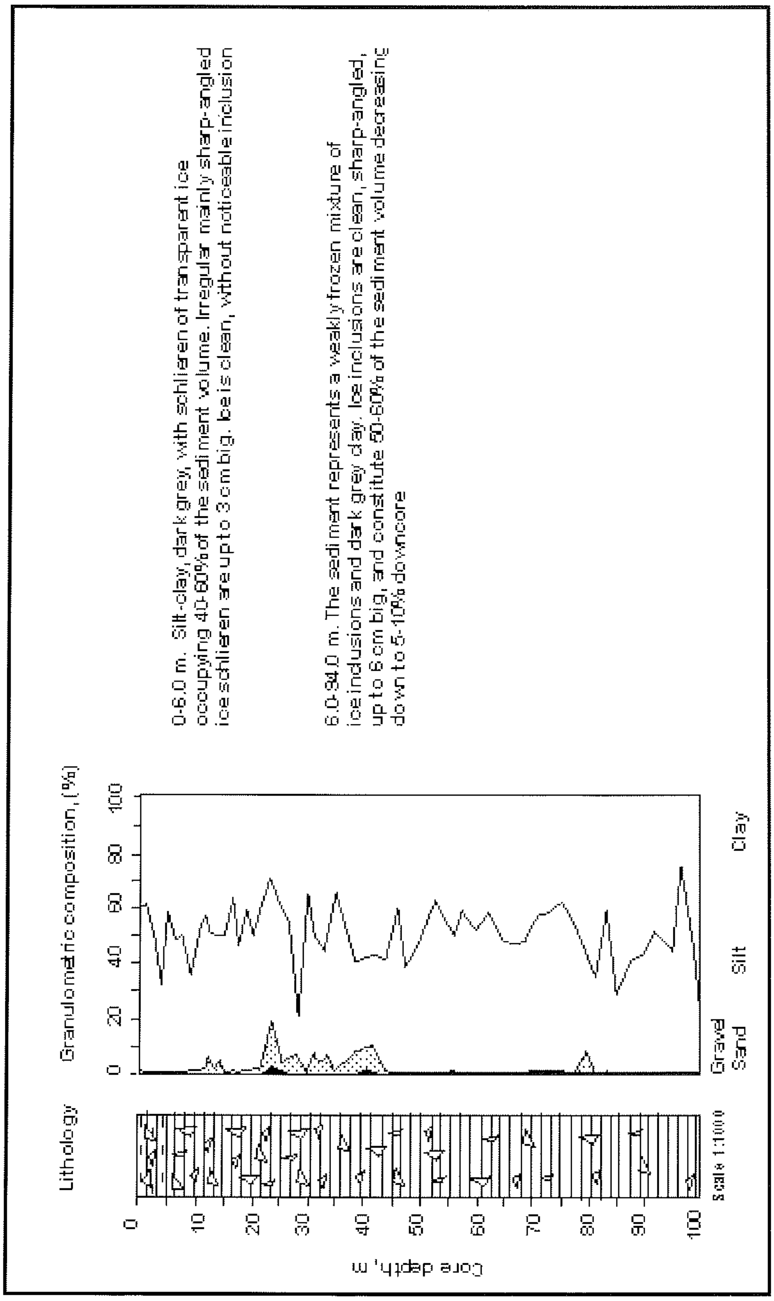

Fig. 4. Lithology and granulometric composition of sediments in core 480

From the lithodynamic point of view, it is interesting to investigate the area with elevated thickness of the Holocene sediments stretching in sub-latitudinal direction from 52° and 58° E. Here, the thickness of the Holocene sediments exceeds 5 m,

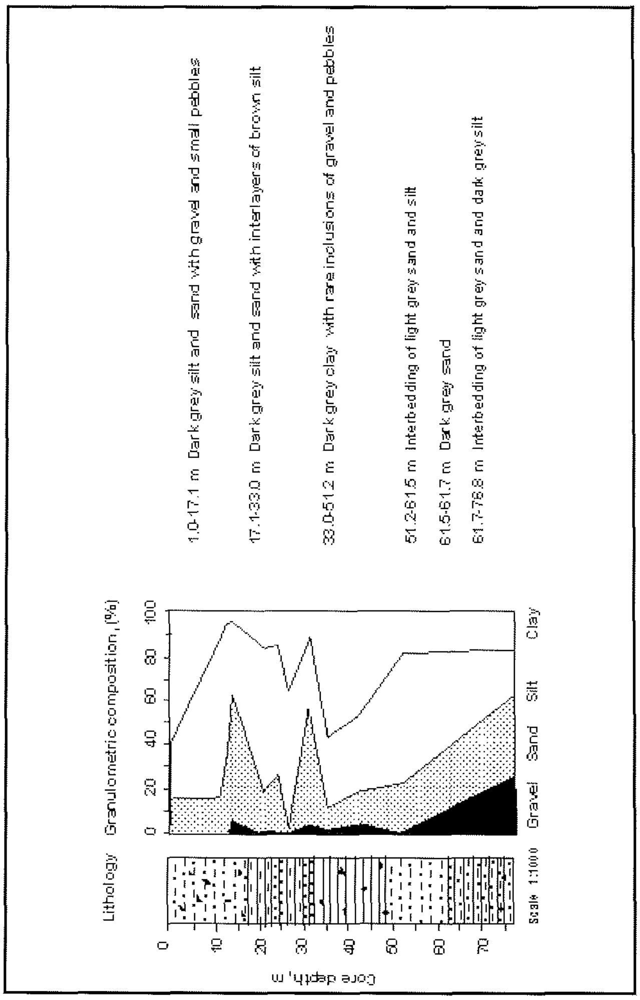

Fig. 5. Lithology and granulometric composition of sediments in core 137

and at two sites even 10 m. It decreases with water depth. It should be mentioned that this area is oriented across the strike of the known neotectonic structures. The elevated thickness of the Holocene sediments in this area, which is restricted to water depths between 35 and 55 m might be attributed to decreasing wave impact on bottom sediments and, thus, active accumulation of sediment particles. On the other hand, the prevailing currents are only capable to carry suspended load. Thus, a big accumulative sediment body is being formed here. However, it is not well defined in the bottom relief. The mechanism of its formation resembles that of a submarine bar.

Accumulation of the fine-grained fossiliferous sediments in the southern Pechora Sea started 9.5-8 ka. Complex analysis of organic remains and sediment structure revealed a river-affected shallow environment.

The Holocene sequence is subdivided into three units: transgressive sands accumulated about 10-8 ka; marine clay with microfossils dating back to approximately 8-5 ka; and marine sands enriched in molluscan shells that have been accumulated since 5 ka. Microfaunal assemblage allows distinguishing the layers corresponding to the Holocene optimum (Fig. 6). Three units of the Holocene sequence could be traced in most studied and age-constrained core sections (Samoilovich et al., 1993; Mel'nikov and Spesivtsev, 1995; Kupriyanova, 1999; Levitan et al., 2000; Polyak et al., 2000).

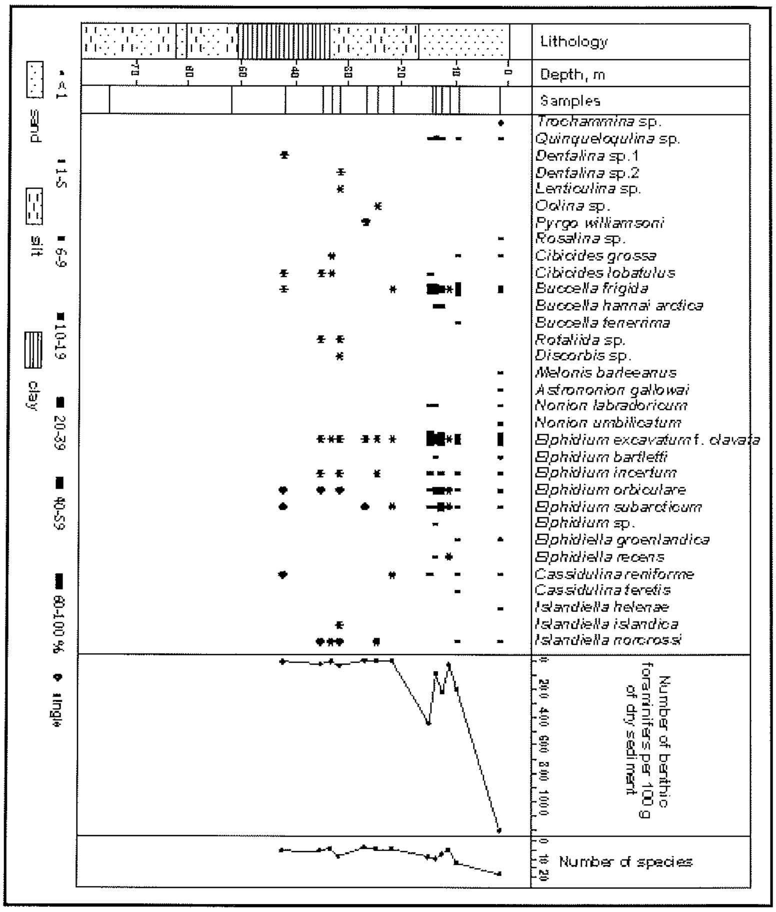

Fig. 6. Relative abundance (%) of Foraminifera species in core 137

Conclusions

In the Pechora Sea region, the Mikulino interglacial was the warmest period of the Quaternary epoch. Climatic parameters of this epoch considerably differ from the Holocene. During the Mikulino interglacial, the forest boundary shifted northward, and hydrological characteristics of water masses were different. The early Valdai cooling gave rise to thick ice sheets, which covered the Pechora Sea and reached the Pechora Lowland. Deglaciation of the Pechora Sea region was completed in the middle Valdai, about 35-40 ka. During the Karga warming climatic conditions were temperate cool, i.e. similar to the modern ones. Sea-level fall after this short interstadial period gave rise to establishment of continental environments. The Pechora Sea floor was exposed and represented coastal marine, alluvial-marine, and alluvial-lacustrine plains subjected to active cryogenic processes and permafrost formation. In the late Valdai, the Novaya Zemlya ice sheet occupied only the northernmost Pechora Sea and did not reach the Pechora Lowland. In the course of the subsequent Holocene transgression the shelf was abraded by the advancing sea. The modern lithodynamic conditions in the Pechora Sea determine accumulation of sandy-silty deposits.

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