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Palynological Characteristics of the Bottom Sediments of the Southern Barents Sea

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Abstract—The distribution of spores and pollen grains was studied in nine sections of bottom sediments up to 50 m thick, in the southern Barents Sea. The Early Cretaceous, Pleistocene, and Holocene ages of the enclosing sediments are determined by palynological analysis. Three Holocene provinces were recognized and traced along the beds, which were formed in the Early, Middle, and Late Holocene according to the scheme of Neishtadt (1957).

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INTRODUCTION

The Barents Sea is an extremely important source of minerals, the exploration of which requires an understanding of its Quaternary sediments. Palynological analysis is the only biostratigraphic method that allows correlation of heterofacial terrestrial and marine sediments. Therefore, this method plays a leading role in the development of detailed stratigraphic charts of the latest deposits, serving as a basis for explanatory notes for large and medium scale geological maps.

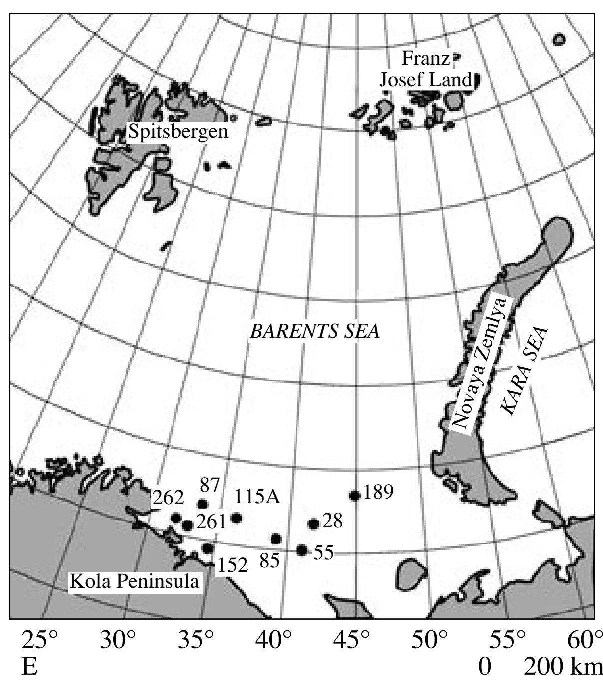
MATERIAL AND METHODS

We studied core and borehole samples (sections up to 50 m in thickness) from the southern region of the Barents Sea (figure) that were collected by the Murmansk Marine Biological Institute of the Kola Research Center of the Russian Academy (MMBI) of Sciences and the Arctic Marine Research Geological Expedition during 1988–1991 (Sharapova, 2005a, 2005b).

The samples for palynological analysis were collected every 10–20 cm in subsurface nonconsolidated sediments and every 1 m in underlying moraine and pre-Quaternary deposits. Each sample of rock analyzed was 60–80 g of watered aleurites and silts, 90–120 g of dense aleurites and clays, and 100–150 g of sands. The primary treatment was made after Grichuk (Grichuk, 1940; Grichuk and Zaklinskaya, 1948).

RESULTS

A thorough analysis of the distribution of spores and pollen grains in the sections studied allowed the establishment of complex biostratigraphic (palynological) zones with boundaries that do not always coincide with lithological levels. The term *biostratigraphic zone* is used here in accordance with the Stratigraphic Code: "A Biostratigraphic zone is a group of layers that is characterized by a specific taxon or an assemblage of ancient organisms (zonal assemblage) that differs from those in underlying and overlying deposits and has lower and upper biostratigraphic boundaries" (*Stratigraphic Code…*, 1992, p. 45). The correlation of the deposits studied was accomplished by the biozonal method (Zhamoida, 1988; *Zonal Stratigraphy…*, 1991;



Map of the region, showing the sections under study.

Koren' et al., 1995; Prozorovskii, 2003). I also used the paleoecological method: the succession of palynological assemblages corresponding to cool and warm periods was revealed, and these assemblages were correlated along the strike (Stepanov and Mesezhnikov, 1979). Holocene sediments were classified according to the scheme of Neishtadt (1957).

The Quaternary deposits of the southern Barents Sea are underlain by Lower Cretaceous deposits that enclose the palynological assemblage dominated by the index Early Cretaceous spores of *Gleichenia angulata* Bolkhovitina, *G. laeta* Bolkhovitina, *Lygodium echinaceum* Verbizkaja, and *Anemia tricostata* Bolkhovitina as well as *Gleichenia* sp., *Sphagnum* sp., *Coniopteris* sp., *Selaginella* sp., *Lygodium* sp., *Anemia* sp., members of the Schizaceae and pollen grains of *Pinites* sp., *Piceites* spp., *Ginkgo* sp., *Podozamites* sp., and *Podocarpus* sp. (Sharapova, 2005a, 2005b).

The lithological composition allows the correlation of the overlaying Quaternary sediments with the horizons established by Andreeva et al. (2002). At the bottom of the section, dense clays with abundant pebbles and gravels of different sizes are situated. These beds contain numerous reworked ancient palynomorphs and solitary Quaternary pollen grains and spores. The beds are correlated with the Yuzhnobarentsovskian Horizon. The total thickness of these beds is 22–23.5 m. Some authors refer the Yuzhnobarentsovskian Horizon to the Upper Pleistocene glacial sediments (Pavlidis et al., 1998; Matishov et al., 2001; Svendsen et al., 2004). However, the Yuzhnobarentsovskian Horizon has not been precisely dated in any deposits. In the southern region of the shelf, the upper boundary of this horizon is situated precisely below the layers that are dated as 13000 ^{14}C BP (Polyak et al., 2000; Gataullin et al., 2001).

The structures under study may have been formed by the Late Valdai Glacier, which reworked older sediments or, in some regions of the shelf, by several glaciations, during which there was no vegetation on the coast. Isolated pollen grains of Quaternary plants were redeposited from earlier interstadial (interglacial?) beds. In section 28, dense clays are underlain by sands with interlayers of aleurites, coal particles, plant debris (12.7 m of visible thickness), characterized by an assemblage of Quaternary pollen grains and spores, reflecting interstadial (interglacial?) conditions. The absence of absolute dating prevents the dating of the beds more precisely than the Pleistocene.

The Upper Valdai glacial sediments are covered with gray and brown clays, which contain numerous reworked Mesozoic palynomorphs and a small number of Quaternary spores and pollen grains. The thickness of the complete section of these beds in the region under study is 20.8 m. Lithologically, the beds are correlated with the Severokaninskian Horizon, which is correlated to Upper Valdai glacial-marine sediments. Gataullin et al. (2001) date the upper boundary of the Severokaninskian Horizon in the southern region of the shelf as 10000 ^{14}C BP.

Upwards in the section, watered aleurites, sands, and silts are situated; they facially alternate over the area of the basin. Lithologically, the beds are correlated with the Annenskian Horizon. These sediments are radiocarbon-dated to the Holocene (Andreeva et al., 2002). Palynological analysis revealed within the Holocene structures of the shelf three provincial zones (bottom-up). Section no. 55, which is maximally complete (figure), was chosen as the stratotype of the provincial zones. Six lithological layers were recognized within the section:

(1) Depth 50–38 m, siltstones in the lower part of the interval and gray sandstones with carbonate cement in the upper part;

(2) 38–19.5 m, dark gray dense clays with pebbles and gravel;

(3) 19.5–14 m, dark gray plastic clays, with small amount of fine gravel;

(4) 14–11 m, greenish gray aleurites;

(5) 11–1.1 m, greenish gray aleurites; in the interval 11–6 m, rare grains of gravel; and

(6) 1.1–0 m, medium-grained sands with shell fragments and plant debris.

Layer 1 contains a palynological assemblage that is typical of the Lower Cretaceous deposits of European Russia. Layer 2, Upper Valdai glacial sediments, also contains exclusively Early Cretaceous taxa. The assemblages of layers 3 and 4 include redeposited Early Cretaceous forms and solitary Quaternary members: *Picea abies* (L.) Karsten, *Pinus sylvestris* L., *Betula* sp., Cyperaceae, Chenopodiaceae, Ranunculaceae, Fabaceae, *Artemisia* sp., Polypodiaceae, and *Sphagnum* sp. The share of in situ Quaternary taxa increases sharply in the assemblages of layers 5 and 6; this makes it possible to reveal three palynological zones in the sediments (the percentage of particular pollen taxa was calculated against the total number of pollen grains, and the percentage of spore taxa against the total number of spores).

Palynological Zone 1-55 (11–5.5 m). Pollen grains of trees prevail (51–70%); in the upper part of the zone, the role of spores increases (up to 47%). The most common tree taxa are *Betula* spp. (26–41%), *Pinus sylvestris* (9–30%), *Picea abies* (7–19%), *Alnus incana* (L.) Moench (1–6%), and *Salix* sp. (1–6%). Among herbs (2–18% of the total assemblage), pollen grains of Cyperaceae, Chenopodiaceae, Fabaceae, Ranunculaceae, *Artemisia* sp., and *Ephedra* sp. were found. Among spores, sphagnums dominate (36–63%), the percentage of the Polypodiaceae is 29–43%, and *Lycopodium* is 0–11% in the lower part of the interval and 36% in the upper part. The concentration of pollen and spores is six to eight specimens per gram. There are 21–75% of reworked Early Cretaceous palynomorphs.

Palynological Zone 2-55 (5.5–1.1 m). The lower boundary of this palynological zone is marked by an increase in *Alnus incana* and the appearance of *Quercus robur* L. and *Acer platanoides* L. In palynological spectra, pollen grains of trees prevail (59–70%). Among them the most common are *Betula* spp. (16–44%) and *Pinus sylvestris* (24–50%). The percentages of *Picea abies* and *Alnus incana* are is 4–12 and 6–10%, respectively. Herbs constitute 6–23% of the total and include Chenopodiaceae, Fabaceae, Ranunculaceae, Apiaceae, Rosaceae, and Asteraceae. Spores are dominated by sphagnums (50–69%). There are 30–50% of the Polypodiaceae and 0–5% of *Lycopodium*. The concentration of pollen grains and spores is seven–nine specimens per gram. There are 22–29% of reworked Early Cretaceous palynomorphs.

Palynological Zone 3-55 (1.1–0 m). The lower boundary of this zone is marked by an increase in the proportion of *Pinus sylvestris* and *Picea abies.* The assemblage is dominated by tree pollen (54–74%); *Pinus sylvestris* is the most common (48–49%), the percentage of *Betula* spp. is 26%; the proportion of *Picea abies* increases (17–19%) and that of *Alnus incana* decreases (2–3%) in comparison with Palynological Zone 2-55. Herbs constitute 2–6% of the total. Dominating herbs are Fabaceae and Chenopodiaceae. Among spores, the Polypodiaceae (46–48%) and *Sphagnum* sp. (40–48%) prevail. *Lycopodium* (5–10%) is less abundant. The concentration of pollen and spores is 12–23 specimens per gram. The proportion of reworked Early Cretaceous palynomorphs is up 2–4%.

Local palynological zones of different Holocene sections of the southern Barents Sea differ because of different sedimentary conditions (figure). However, the presence of characteristic taxa allows one to trace the zones over most of the area studied and to establish three provincial zones (Sharapova, 2005a).

The **Betula Provincial Zone**, which occupies the basal portion of the section, is formed by greenish gray aleurites (1–5.5 m thick) and is underlain by plastic light gray clays of the Severokaninskian Horizon. Its lower margin is marked by a sharp increase in the concentration of pollen and spores. The zonal assemblage is characterized by dominating *Betula* (26–61%). The percentage of *Pinus sylvestris* is 9–30%, *Picea abies* is 2–19%, and *Alnus incana* is 1–6%. Pollen grains of *Salix* (1–6%) occur only in coastal sections. Herbs are not numerous (2–18%). Most common are the Cyperaceae, Poaceae, Chenopodiaceae, Fabaceae, and Ranunculaceae. The spores are dominated by *Sphagnum* sp. and the Polypodiaceae.

The **Alnus–Quercus Provincial Zone** is formed by sands and greenish gray aleurites, facially alternating over the area of the basin (0.4–8.3 m thick). The lower boundary is determined by the appearance of isolated pollen grains of broad-leaved trees and the increased proportion of *Alnus incana.* The zonal assemblage is characterized by the maximal percentage of *Alnus incana* (up to 30%) and isolated pollen grains of broad-leaved trees: *Acer platanoides, Quercus robur, Tilia cordata* Miller, *Ulmus glabra* Hudson, and *Fagus sylvatica* L. Pollen grains of *Betula* (34–83%) and *Pinus sylvestris* (11–50%) prevail in the assemblage. The proportion of pollen grains of *Picea abies* is 0–15%. The proportion of pollen grains of *Salix* varies from 2 to 9% in coastal regions, and decreases down to complete disappearance with increasing distance from the shore. Herbaceous plants (4–25%) are represented mostly by pollen grains of Fabaceae, Ranunculaceae, Asteraceae, Polygonaceae, and Rosaceae. The spores are dominated by *Sphagnum* sp. and Polypodiaceae, the proportion of the latter decreasing with increasing distance from the shore.

The **Alnus–Quercus Provincial Zone** succeeds the *Betula* Provincial Zone in sections 55 and 28. In sections 152, 261, 262, and 189, the lower boundary of the palynological zone is not visible. In sections 85 and 87, judging from the palynological spectra, the *Alnus–Quercus* Provincial Zone overlies with scour marks the light brown plastic clays of the Severokaninskian Horizon.

The **Pinus–Picea Provincial Zone** is represented by greenish gray aleurites and sands, facially alternating along the area of the basin (0.15–1.5 m thick). Its lower boundary is determined by a sharply increased proportion of pollen grains of *Pinus sylvestris* and *Picea abies.* The zonal assemblage is characterized by dominating *Pinus sylvestris* and the maximum recorded number of *Picea abies.* The palynological assemblage is dominated by *Pinus sylvestris* (25–74%). The proportion of *Betula* is up 7–32%, and *Picea abies* is 2–23%. In comparison with the *Alnus–Quercus* Provincial Zone, the proportion of pollen grains of *Alnus incana* decreases (0–8%), and pollen grains of broad-leaved trees disappear. The proportion of herbs is 10–33% near shore and 0–10% offshore, mostly comprising Cyperaceae, Poaceae, Chenopodiaceae, Fabaceae, Ranunculaceae, and Asteraceae. The spores are dominated by *Sphagnum* sp. or Polypodiaceae. The *Pinus–Picea* Provincial Zone replaces the *Alnus–Quercus* Provincial Zone.

CONCLUSIONS

Paleoecological analysis of the palynological assemblages leads us to the conclusion that the *Betula* Provincial Zone was formed in the Early Holocene. The warmest climatic conditions are recorded in the *Alnus–Quercus* Provincial Zone, which is referred to the Middle Holocene. The *Pinus–Picea* Provincial Zone reflects a new cooling episode and is correlated with the Late Holocene.

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