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GEOLOGY

Distribution of the Thickness of Quaternary Sediments and Principal Features of the Pre-Valdai Surface in the White Sea

G. A. Tarasov[a] and V. V. Shlykova[b]

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Friable sediments of different glacial and interglacial epochs are abundant in the White Sea and adjacent land areas influenced by Pleistocene glaciations. Numerous studies carried out in neighboring areas of the Kola and Kanin peninsulas and Karelia provide grounds to conclude that glacial–periglacial sediments

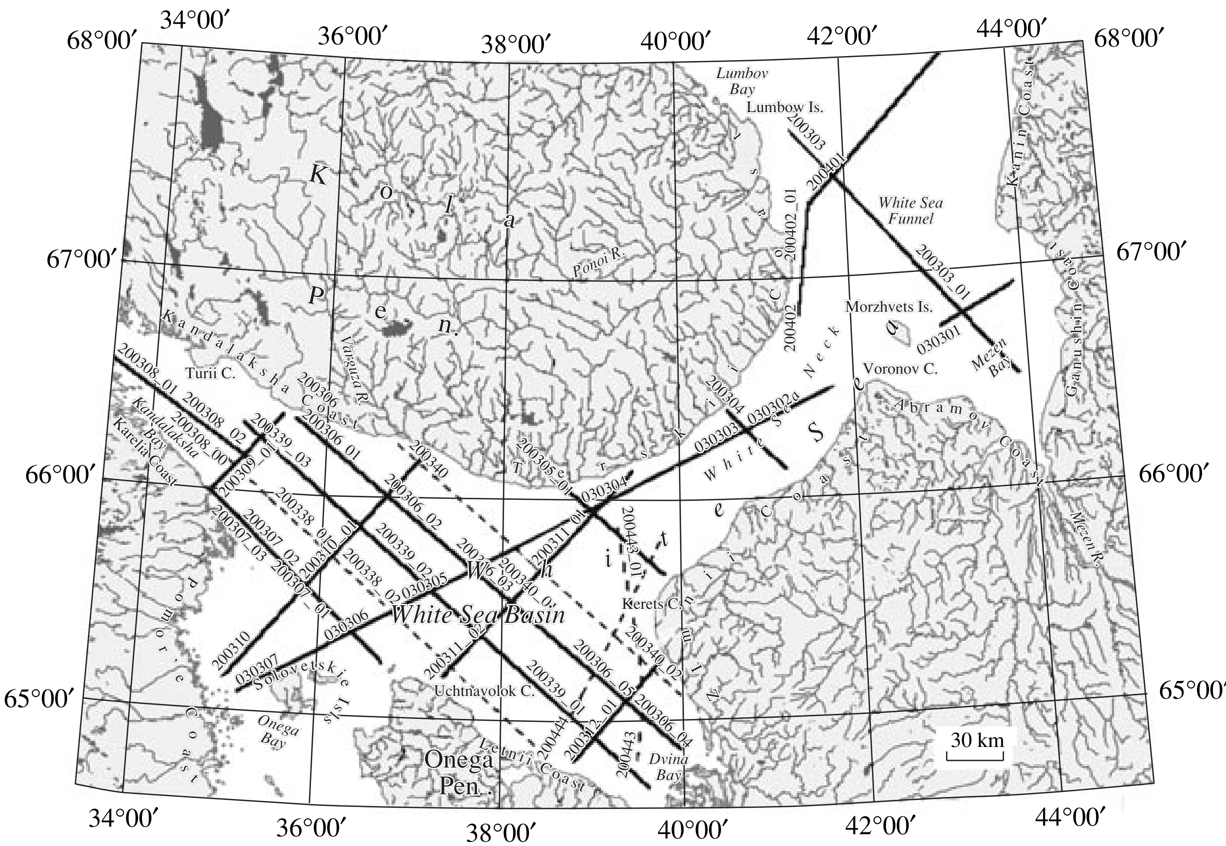

Fig. 1. Schematic location of seismoacoustic profiles.

[a] Murmansk Marine Biological Institute, Kola Scientific Center, Russian Academy of Sciences, ul. Vladimirskaya 17, Murmansk, 183010 Russia; e-mail: tarasov@mmbi.info
[b] Marine Arctic Geological Prospecting Expedition, ul. Sof'i Perovskoi 26, Murmansk, 183072 Russia

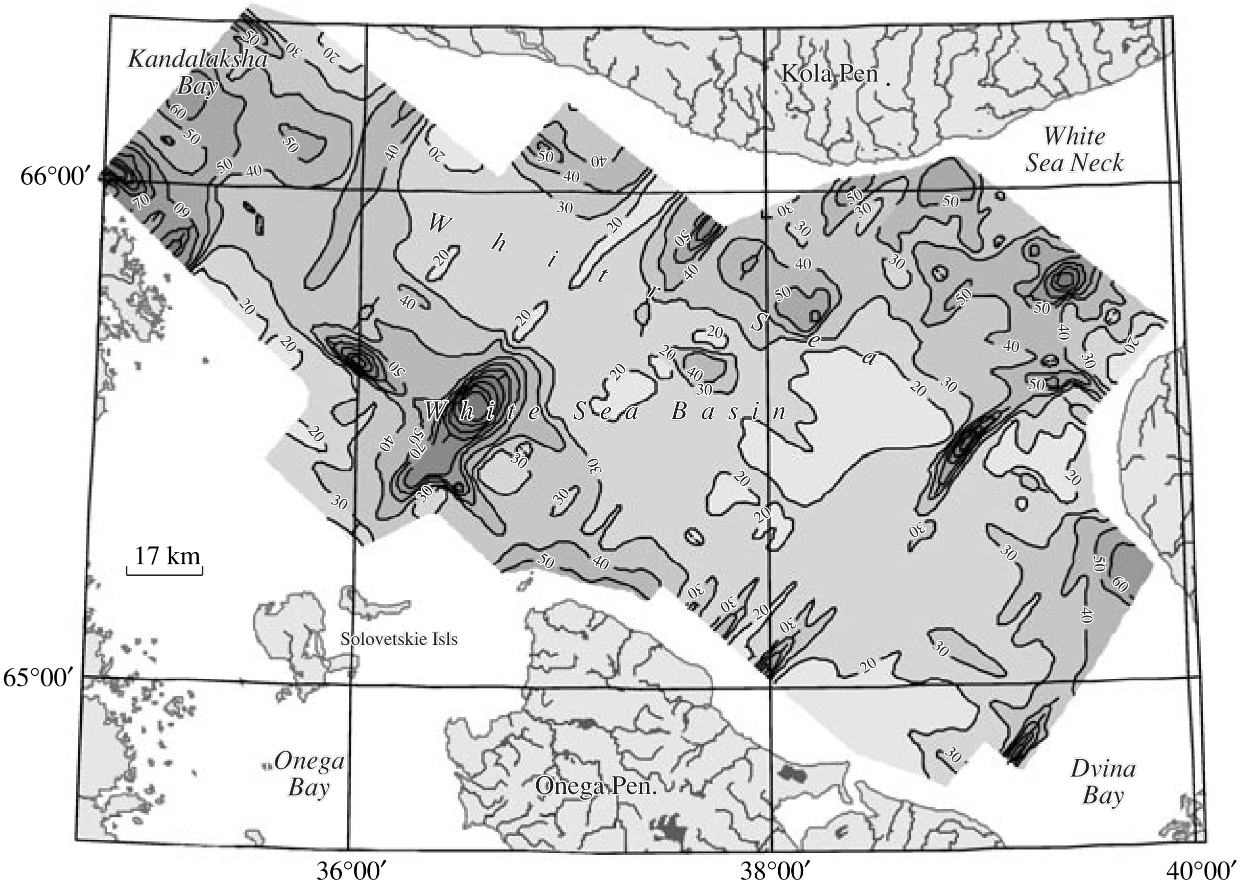

Fig. 2. Isohypses of the base of Quaternary sediments. The step is 10 m.

represent a substantial constituent of Quaternary sequences. Most of the land areas surrounding the White Sea have been studied thoroughly. Detailed paleogeographic maps of the region were compiled, and analysis of its Late Cenozoic evolution was presented based on generalization of the available geomorphological, lithofacies, and geological–geophysical data [1–3].

Nevertheless, data on the geological structure of Quaternary sequences in the White Sea are practically unavailable except for some areas such as, for example, Onega Bay, where geological–geophysical studies were carried out in the 1970s by a team of researchers from the Karpinskii All-Russia Research Institute of Geology (St. Petersburg) under the supervision of M.A. Spiridonov [4], and the White Sea Neck area mapped at a scale 1: 200000 by the Arkhangel'skgeologiya Industrial Enterprise [5]. Consequently, best studied are the White Sea Neck, Onega Bay, and the adjacent offshore areas, while the central part of the sea remains insufficiently explored. Only surface sediments up to 3–5 m thick recovered by simple piston corers have been studied [6].

The main purpose of our studies was to elucidate the geological structure and distribution of Quaternary sediments through the White Sea based on the analysis of geological–geophysical materials obtained by the Murmansk Arctic Geological Expedition in 2003–2004 (Fig. 1). We mainly used continuous seismic profiling records obtained in the course of geological mapping (scale 1: 200 000). The only WRM-CDP profile was carried out along the profile extending from the Kanin Peninsula to the central part of the White Sea (Sevmorgeofizika Enterprise).

The surface of pre-Quaternary sediments on the eastern White Sea shelf represents a structural–denudation plain slightly inclined toward the central part of the deep-water depression plain dissected by preglacial incisions that are confined to tectonic fractures. In the western half of the shelf, the pre-Quaternary surface hosts a spacious NW-trending trough-shaped depression more than 200 m deep. The depression extends from the Letnii Navolok Cape (northern Onega Peninsula) to the upper reaches of Kandalaksha Bay (Fig. 2). The southern and northern walls of the depression are steep, particularly on the beam of Onega Bay. In the eastern part of the study region corresponding to Dvina Bay and the White Sea Neck area, the preglacial relief is composed of Vendian rocks, which continue to Onega Bay [4]. The Vendian sequence penetrated by

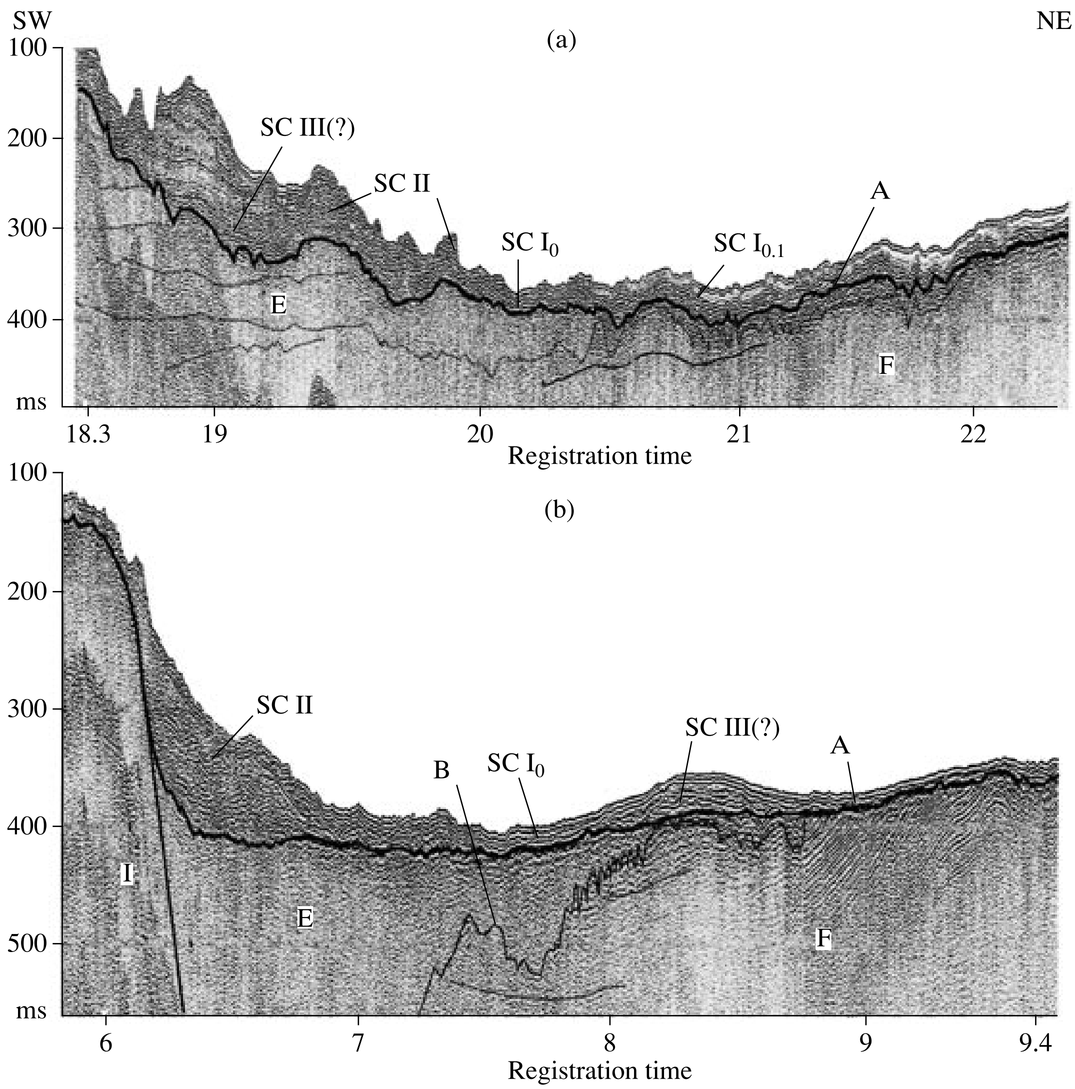

Fig. 3. Fragments of CSP time sections along profiles (a) 200 309 and (b) 200 310. (A) Base of Quaternary sediments; (B) roof of Riphean rocks; (E) Riphean SC; (F) Paleozoic–Cenozoic SC; (I) Proterozoic SC.

boreholes in the White Sea Neck area consists of clays, argillites, siltstones, and sandstones [5]. The surface of Riphean and Paleozoic rocks occupies the major part of the White Sea and Kandalaksha Bay. Seismic profiles across the Kandalaksha Bay mouth show distinct stratification and gentle folding of pre-Quaternary (presumably Early Paleozoic) sequences.

The pre-Quaternary surface of the White Sea Basin is overlain with stratigraphic unconformity by glacial and fluvioglacial sediments. Based on the interpretation of time sections, they can be subdivided into the following seismoacoustic complexes (SC): (SC III) interglacial (Mikulino) complex, (SC II) moraine (border, lateral) complex, and (SC I) Holocene (Recent) glaciomarine and marine complex (Fig. 3). Based on wave patterns, the Holocene complex is divided into the following subcomplexes: (SC I_1) blanket-shaped sedimentary cover; (SC I_0) sediments filling in depressions and smoothing the uneven surface of underlying rocks; (SC I_{11}) the acoustically uniform "transparent" sequence; and (SC_{01}) sediments characterized by less intense seismic reflections.

Isopach patterns of Quaternary sediments show that they are distributed irregularly over the study region (Fig. 4). Their thickness varies from 3 to 150 m (average 30 m), and the distribution of thickness does not depend on the pre-Quaternary topography. The spacious eastern part of the region is covered by loose sediments not more than 20 m thick. The maximal thickness of Quaternary sediments is observed in NE-trending linear parallel structures extending from Kandalaksha Bay toward Dvina Bay. Particularly large morphological structures (hills and ridges) composed of Quaternary sediments are located north of the Solovetskie Islands and in the mouth of the White Sea Neck. These prominent underwater hills and ridges represent marginal (terminal) moraines formed at the front

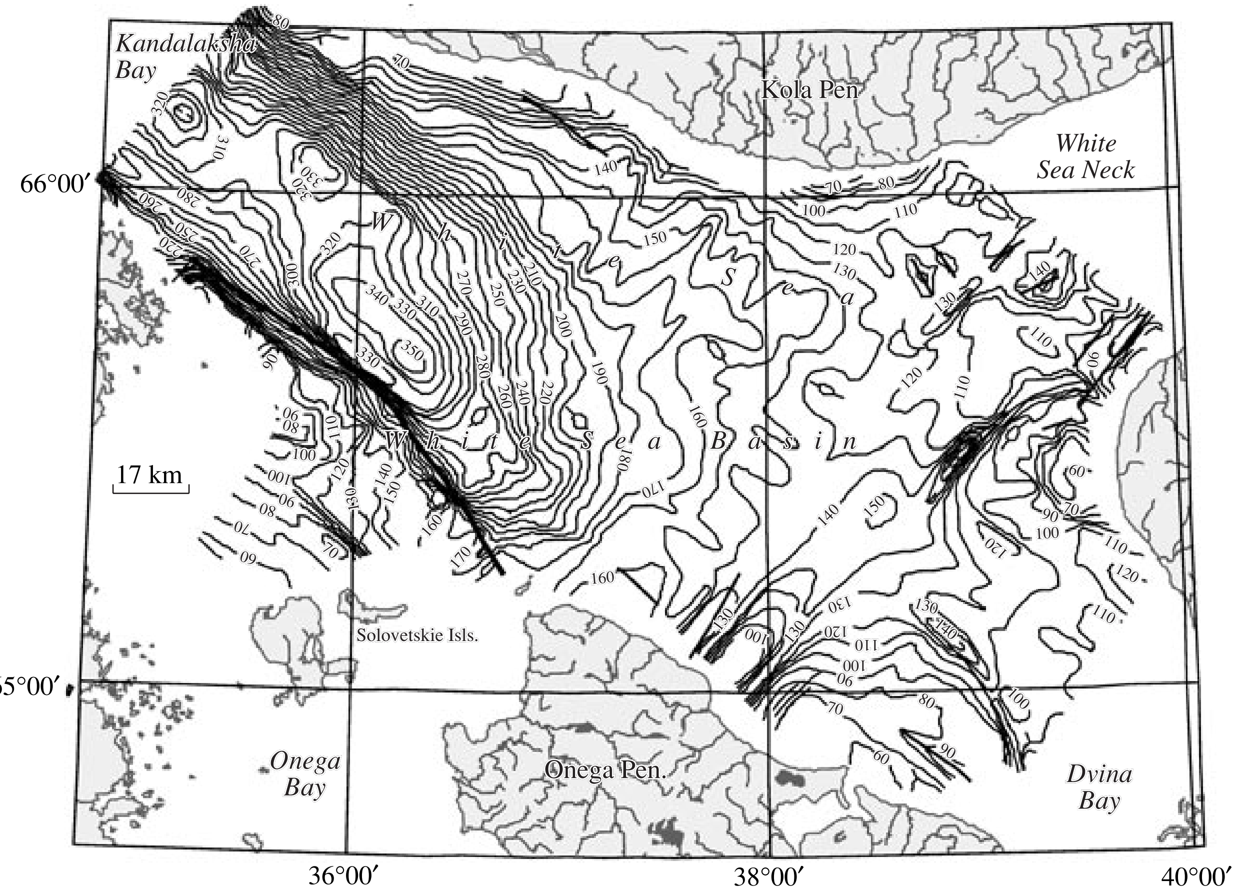

Fig. 4. Thicknesses of Quaternary sediments. Isopachs are given with a step of 10 m.

of the glacier tongue and serve as proxies of the former glacial tongue at different stages of glaciation [1].

Analysis of the seismoacoustic profiles shows that terminal moraines of the White Sea Basin are variable in size and thickness of sediments. In plane view, they form extended positive structures several hundred meters long and several meters high. The largest structures are several tens of kilometers long and approximately 100 m high. Glacial sediments of the last glaciation usually overlie the preglacial surface. Older sediments of the Mikulino Glaciation are confined to incisions in the bedrock surface. These sediments are 15 m thick in the White Sea Neck. The Mikulino marine sequence includes sand and silt with an admixture of shelly debris and detrital (clayey to coarse-grained) material [5].

The last (Valdai) glaciation, which followed the Mikulino Glaciation, was the smallest among all Quaternary events [1]. Correspondingly, the distribution and thickness of Valdaian sediments were inferior to sediments of previous glaciations. The White Sea Basin hosts only traces of the last glaciation, which completely destroyed the older loose sediments. The highest phase of the last Scandinavian glacier was probably characterized by the penetration of its South Kola ice flow into the Kandalaksha Trough and further to the White Sea Basin. The ice flow subsequently covered Onega and Dvina bays. The glacier rested upon the bottom of the sea and scavenged the whole loose sedimentary sequence during its northeastern movement. At the deglaciation stage, glacier bodies in the forms of hills and ridges were left on the depression bottom.

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