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GEOGRAPHY

New Data on the Late Quaternary Stratigraphy and Paleogeography of the Wijdefjorden Region (West Spitsbergen)

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The World Ocean region with Spitsbergen Archipelago is one of the most indicative areas in terms of paleogeography for assessing global climatic fluctuations in the late Quaternary and for their long-term prediction.

We carried out geomorphological, lithological, and faunal studies on the Wijdefjorden eastern coast in the southern Ny Frisland Peninsula (figure). A series of well-defined accumulative–abrasion marine terraces composed of sediments 2–5 m thick was revealed here within the Flatoyrdalen outwash valley springing from the Cookbreen outlet glacier (figure). Proterozoic bedrocks or Late Pleistocene sedimentary rocks occur in the terrace socle. The terraces differ slightly in height and include narrow (up to 200 m) benches complicated by beach ramparts up to 1 m high. Terrace edges are prominent. Benches are slightly inclined to the sea, rarely flat, and waterlogged in places. Terrace joints are partially veiled by solifluction sediments. Marine terraces are divided into the following levels (m): 4–5, 10–12, 16, 18, 21–22, 25–28, 30–31, 42–45, and 65. Sediments of marine terraces comprise diverse and abundant microfauna assemblages. In terms of index species of mollusks, the marine terraces include the following assemblages: *Astarte borealis* and *Serripes groenlandicus* (up to 5 m); *Mytilus edulis* (5–12 m); *Mya truncata* and *Hiatella arctica* (12–65 m). The geodetic coordination of the Quaternary reference section allowed precise recording of the altitudes for morphological elements of the terraces. A series of samples was collected on their surface and in sections for micro- and macrofauna analyses. The absolute ages were established by radiocarbon dating based on *Mya truncata* shells and *Balanus balanus* loricae (table).

In the section of the Flatoyrdalen marine terraces, we distinguished three stratigraphic horizons (figure) consecutively reflecting the stages of the Late Pleistocene–Holocene evolution of the region.

Horizon 1 comprises the lower part of the reference section (exposure 115) and belongs to the middle Valdai time interval (middle Weichselian time according to the European scale) known in Spitsbergen as the Ekholm Interstadial [10]. Marine sedimentation conditions existed during the active melting of glaciers and large-scale drift of mineral particles to the fjord. The consequent light regime was unfavorable for phytoplankton evolution and responsible for low bioproductivity in the basin. This is evidenced by the peculiar foraminifer assemblage found in the studied sediments: abundance (75%) of the dominant species *Elphidium excavatum* f. *clavata*, which is tolerant to conditions of low supply of nutrients to the bottom; sharp variations in salinity and temperature; depleted taxonomic composition (10 species); and small dimensions of shells.

Horizon 2 is represented by a moraine sequence of late Valdaian (late Weichselian, according to the European scale) glacial structures. Judging from the presence of boulders with enveloping structures in the moraine, the lower part of Horizon 2 formed in the marine basin beneath the glacier body.

Horizon 3 includes sediments formed during the Early Holocene transgression, probably under glacimarine conditions. The horizon is noted for clastic material of Devonian rocks, bedrock exposures of which are known only on the opposite shore of Wijdefjorden

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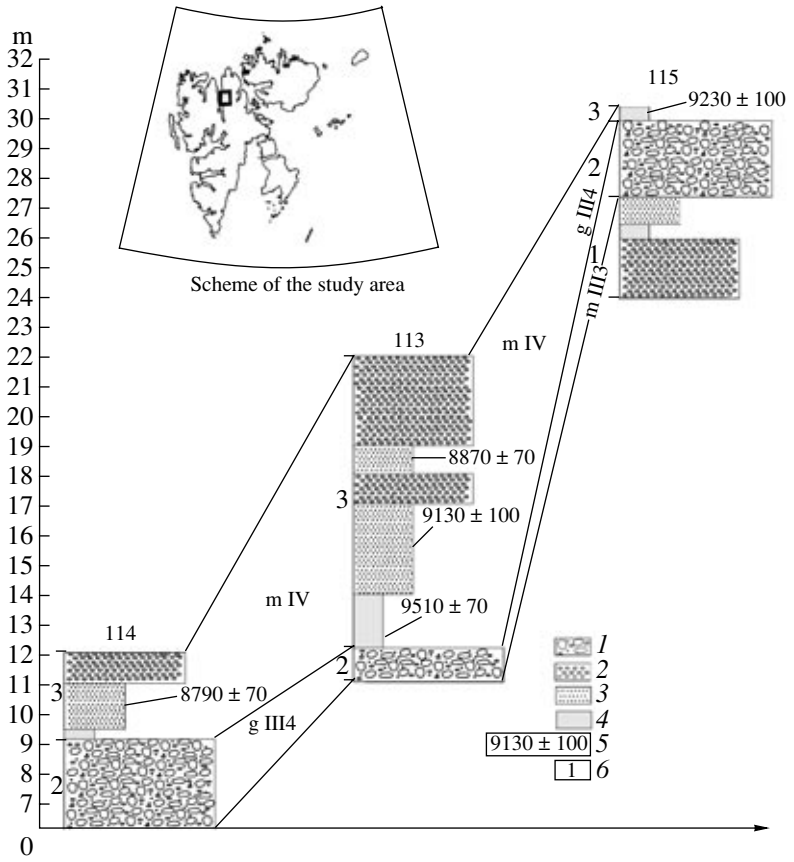

Correlation of Quaternary deposits in the Flatoyrdalen valley. (*1*) Till; (*2*) pebble, gravel; (*3*) sand; (*4*) silt; (*5*) radiocarbon ages; (*6*) numbers of stratigraphic units. Inset shows the scheme of the study area (box).

(Andre Land). Silts from the lower part of the sequence yielded a rich, diverse, and ecologically persistent assemblage of benthic foraminifers with dominant *Elphidium excavatum* f. *clavata* and *Cassidulina reniforme* species. The species composition is characteristic of the inner parts of Arctic bays [2, 3]. The subdominant species in nearly all the samples is *Nonionellina labradorica*, a potential indicator of high-productive conditions. In the Spitsbergen fjords, the wide distribution of this species, which is confined in the Barents Sea to the Polar front zone [4], is established at the boundary of transformed Atlantic and local watermasses [3] characterized by a high content of phytoplankton. The assemblage structure indicates the accumulation of sediments under conditions of a seasonal influx of organic material to the bottom during the inflow of Atlantic warm waters into the fjord. The radiocarbon age of fragments of *Balanus balanus* loricae (9510 ± 70 yr) from this horizon gives insight into the timing of its formation. The large sizes of *Balanus* loricae also indicate that optimal hydrobiological conditions existed there about 9500 yr ago. The tendency for a decrease in the bathymetric optimum of the habitat for these barnacles during global warming events [5] suggests that the sed-

Radiocarbon datings (Spitsbergen Archipelago, West Spitsbergen Island, Wijdefjorden)

Field no.	Lab. no.	Altitude, m	Material	Abs. age, yr
S-114	LU-5406	10.3	*Mya truncata* shells	8790 ± 70
S-113-1	LU-5409	18	The same	8870 ± 70
S-113-2	LU-5410	14.3	"	9130 ± 100
A-113-3	LU-5408	12	Fragments of *Balanus balanus* loricae	9510 ± 70
A-115-1	LU-5407	31.5	The same	9230 ± 100

iments formed at a depth of 50–80 m. Shells of thermophile mollusks *Cyprina islandica, Modiolus modiolus, Littorina littorea*, and *Mytilus edulis*, which do not inhabit Spitsbergen waters at present [6, 7], are found in overlying sands (figure) and analogous sediments of the marine terrace on the opposite slope of the valley. This fact also indicates a cardinal improvement in climatic conditions at the end of the early Holocene. We identified the sequence occurring at the top of the horizon (Exposure 113) as Holocene coastal-marine and marine sediments. The character of microfauna from the upper intervals of the section indicates a sequential decrease in the water temperature and salinity, as well as basin shoaling, since 9.2 ka ago.

The analysis of the geomorphologic structure of the shelf and continental slope in the Spitsbergen Archipelago region [8] and numerous radiocarbon dates for marine terraces [9–11] are indicative of a faster reduction of archipelago glaciers compared to ice sheets of Europe and North America. It is suggested that glaciers were of small thickness there 17–15 ka ago, the ice cap center was located on the east beyond the archipelago limits, and near-shore waters west and north of the archipelago could be free of ice [12].

The study of the Flatoyrdalen marine terraces revealed unique features in the early Holocene history of the region. We believe the upper sea level in the region formed about 9.5 ka ago. At that period, the influx of warm waters from the North-Atlantic branch of the Gulf Stream to the northern Spitsbergen region was greater than to the Barents Sea; it is this fact that set up the climatic optimum there earlier (9.5 ka ago) than in the Barents Sea (7.5–5.5 ka ago). This version is consistent with data on the intrusion of some thermophilic mollusk species, particularly *Mytilus edulis*, into northern areas of the archipelago fjords 9.4 ka ago [13, 14], as well as with paleoreconstructions of bottom water temperatures from *Chlamys islandica* shells in the western fjords [6]. At the same time, the situation did not rule out the possibility that active glaciers supplying clastic erratic materials to the open basin existed on the archipelago, particularly on the western coast of one of the greatest fjords—Wijdefjorden. Most of the Wijdefjorden area was occupied by seawater during the early–middle Holocene. It is this period to which the most active rise of the region was related. The rise was determined by two factors: activation of neotectonics and glacioisostasy.

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