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GEOLOGY

Radiocarbon Dates of Late Quaternary Mammals in the Archangelsk Region and Their Contribution to Reconstructions of the Last Glaciation in Eastern Europe

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Abstract—Twelve new AMS (Accelerator Mass Spectrometry) dates of large Quaternary mammal remains were reported: mammoth (*Mammuthus primigenius*), bison (*Bison priscus*), and musk ox (*Ovibos pallantis*) found in the Archangelsk Region. The absolute age of the identified samples varies from 46 000 to 22 000 calibrated years ago. These data suggest that a substantial part of the Archangelsk Region was not covered by ice during the indicated time interval.

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Today, there are a few different points of view concerning the last glaciation chronology and development in the Archangelsk Region (Fig. 1). The Late Valdai glacier cover is the most advanced in the reconstructions of M.G. Grosswald [9], who modeled the Great Arctic glacial shield covering a substantial part of the European north. The glacier also advanced considerably in the last glaciation maximum reconstructed by Kh.A. Arslanov [1, 2] and A.S. Lavrov [4]. According to A.S. Lavrov [4], in the Late Valdai a few glacial ice sheets advanced to the northern part of Eastern Europe: from the Kola Peninsula and adjacent Barents Sea areas (Kola–Mezen' glacier stream), to the Barents Sea areas and Pechora River lower flow (Barents Sea–Pechora glacier stream), the southeastern part of the Barents Sea shelf, Novaya Zemlya Islands, and also the northern part of the Urals (Pai–Khoya) (Novaya Zemlya–Kolva glacier stream). A vast part of the region north of 65° N was covered by ice. Later on, A.S. Lavrov and L.M. Potapenko [5] laid off the boundaries of the Late Valdai Scandinavian and Barents Sea–Novaya Zemlya–Kara glacial shields in close proximity to the boundaries offered by M.G. Grosswald [9]. In their opinion, the glaciation attained its maximum at the isotopic oxygen stage 2 (IOS 2).

According to A.A. Velichko et al. [3, 14], the late glaciation maximum (20–18 thousands uncalibrated years ago) was marked by intensive development of the Scandinavian glacier cover, while other ice caps were limited in occurrence. The Scandinavian glacial shield reached its maximum northeastern boundary (almost from Vologda to the Vaga River middle part) about 24 000 uncalibrated years ago [14].

According to I.N. Demidov et al. [7, 8], E. Larsen [11], and Kjær et al. [10], the Scandinavian glacier maximum advance boundary eastwards passes through the northwestern part of the Kanin Peninsula over the White Sea bottom southwards to the Kuloi River mouth, then reaches the eastern end of the Kuloi Plateau, overlaps the lower and middle parts of the Pinega River, and turns westwards along the Northern Dvina River valley (Fig. 1). The chronological framework of this event is within 18–16 thousands calibrated years ago or about 14.5–12.5 thousands uncalibrated years ago. This point of view on the boundaries and chronology of the Scandinavian glacier coincides for the most part with the opinion of the QUEEN research team [13]. The QUEEN researchers suggest that the White Sea was covered with ice, and the end of the eastern glacier reached the western coast of the Kanin Peninsula, where it was merged with the shelf glacier of the Barents and Kara seas. The valleys of the Vaga and Sukhona Rrivers were flooded by waters of the glacier-dammed lakes with water flowing out into the Volga River and Caspian Sea. The melted glacier waters were unloaded northwards along the glacier

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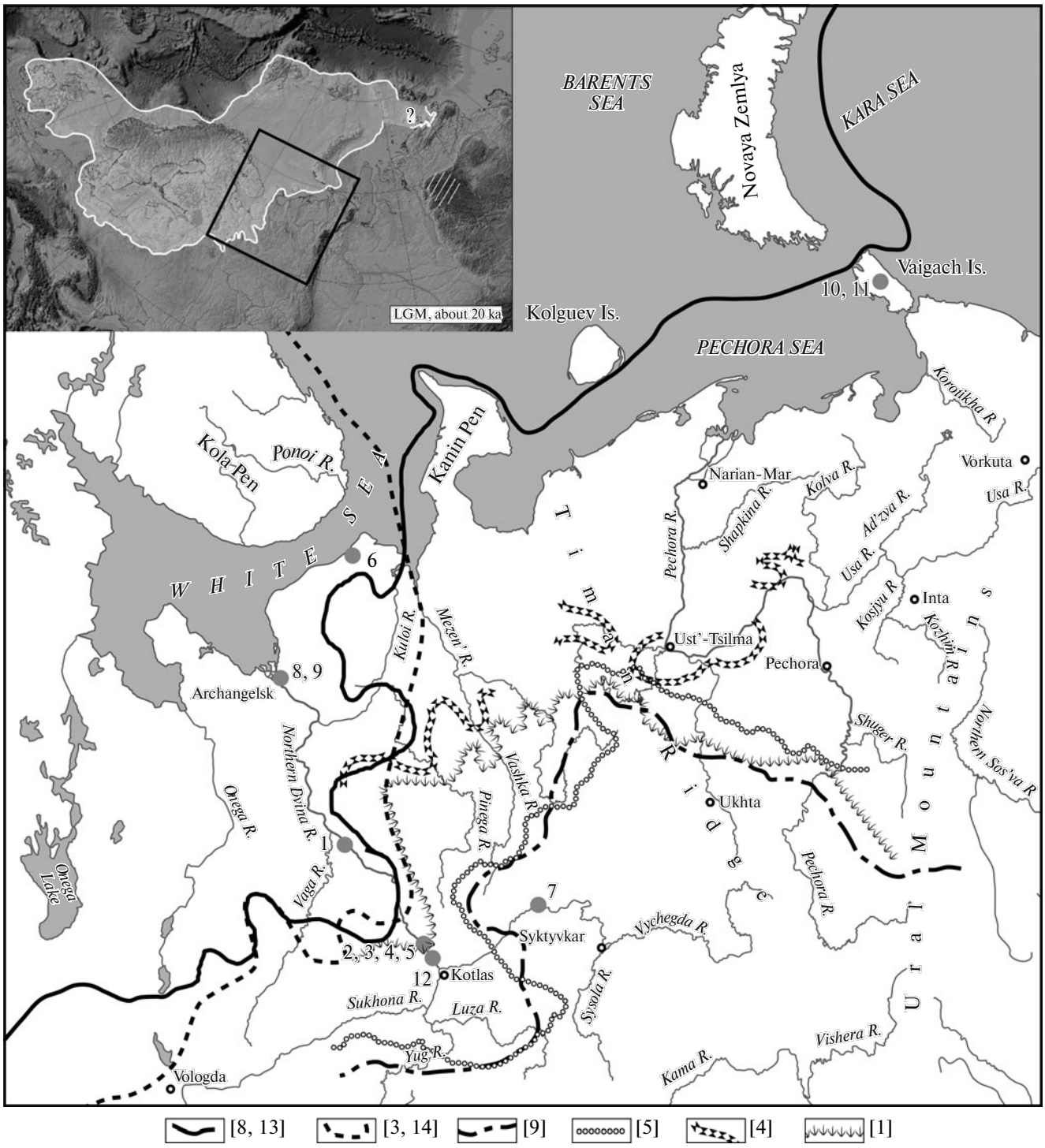

Fig. 1. Dated findings of large mammal remains in the European northeast. Figures correspond to numbers in the table. In the inset, reconstruction of the maximum glacier development during IOS 2 (white contour) [13].

margin, eastwards through the southern part of the Kanin Peninsula, and then between the continent and southern end of the Barents–Kara glacial shield.

The data on findings of Quaternary mammal bones in the Archangelsk Region are rather poor. Having studied the museum collections, V.I. Smirnov [6] obtained and marked on the map the data on findings of 137 large mammal bones in the Vologda and Archangelsk regions, and also in the Komi Autonomous Soviet Socialist Republic. As a rule, these are findings in the riversides without confinement to any particular geological bodies. Most of them are concentrated in

AMS dates of the Quaternary mammal bone remains from the Archangelsk Local History Museum

No.	Museum number	Finding site	Dating material	Date (±σ), radiocarbon years	Laboratory number	Date, calibrated years (1σ)
1	11685	Topsa	Mammoth tooth	24 430 (±110)	GrA 42197	29 440–29 280
2	218/59	Krasnoborsk	Mammoth tooth	21 690 (+120–110)	GrA 42199	26 140–25 890
3	10682(1)	Krasnoborsk	Bison skull	42 400 (+550–450)	GrA 42200	45 970–45 250
4	10682(2)	Krasnoborsk	Bison skull	39 350 (+370–330)	GrA 42201	43 810–43 180
5	10628	Krasnoborsk	Musk sheep skull	41 860 (+500–420)	GrA 42204	45 590–44 940
6	23774	Megra	Mammoth tooth	31 690 (+200–180)	GrA 42205	36 540–36 270 35 800–35 690
7	6997	Bogoslovo	Mammoth tooth	29 530 (±150)	GrA 42206	34 590–34 120
8	19029(1)	Archangelsk	Mammoth tooth	34 590 (+240–220)	GrA 42207	39 980–39 200
9	19029(2)	Archangelsk	Mammoth tooth	18 300 (±70)	GrA 42227	22 020–21 690
10	216/60(1)	Vaigach	Mammoth tooth	24 550 (±120)	GrA 42209	29 500–29 360
11	216/60(2)	Vaigach	Mammoth tooth	32 150 (+210–160)	GrA 42211	36 750–36 520
12	6998	Stepanitsa	Mammoth tooth	28 080 (+140–130)	GrA 42210	32 530–32 000

the southern part of the region (about 60° N) likely due to the development of glaciation in the last glacial maximum.

The mammoth, bison, and musk ox bones from the Archangelsk Local History Museum were subject to AMS dating under the COMSEC project (Collapse of the Mammoth Steppe Ecosystem) focused on establishment of particular space and time features of mammal distribution in Northern Eurasia during Pleistocene-Holocene transition. All bone remains were found along riversides or in the processed material of mines, i.e., without confinement to any particular geological bodies. As a whole, J. van der Plicht (Groningen University, Groningen, Netherlands) dated twelve samples with an age from 45 970 to 21 690 calibrated years ago (table). The radiocarbon datings were calibrated using the IntCal09 scale [12].

It is necessary to note one important specific feature of the studied material concerning the storage and accounting of museum samples. Some pairs of samples (mammoth molars under numbers 19 029 and 216/60) have one number and one registration card; i.e., two different samples have one number and one description. This specific feature of the material suggests some unreliability of the conclusions made on its basis. On the other hand, it is a common practice of many museums to give one number to a few samples from one finding site, and thus we will not ignore such samples.

The studied material provided the possibility to obtain data on the eastern flank of the last Scandinavian glacier (Figs. 1, 2). Most data occur within the chronological and geographic limits of the last glaciation, in the opinion of most scientists [1, 2, 8, 5, 9, 13, 14], staying within the IOS 3 limits. The most interesting datings were made for the mammoth remains from Dvina Topsa (24 430 ± 110 years; GrA 42197), Vaigach (24 550 ± 120 years; GrA 42209), and Archangelsk (18 300 ± 70 years; GrA 42227), falling on the initial and maximum cooling down of the last glaciation. These data are indicative of the fact that even the northern part of the Archangelsk Region was not covered by Scandinavian glaciation ice in the interval of 43 000–18 000 years ago (50000–22000 calibrated years ago). When comparing the obtained data with the reconstructions of the last glaciation in the region, it is obvious that they are in poor compliance with the "maximum" point of view [1, 2, 4, 5, 9], because according to these ideas some findings occur within the time and space limits of the glaciation. Our data also do not confirm the suggestion that the northeastern end of the Scandinavian glacier reached its maximum position about 24 000 years ago [14]. Meanwhile, the reported materials are in good compliance with the suggestion that the northeastern end of the Scandinavian glacier reached its maximum position in the period of 16 000–18 000 calibrated years ago [7, 8, 13]. This idea is confirmed by the findings within the geographical limits, but outside the time bounds (about 4000 years earlier) of the maximum glacier advance. Hence, our data are indicative of the fact that a substantial part of the Archangelsk Region was not covered by ice 50 000–22 000 calibrated years ago and confirm the "minimum" point of view suggesting the limited

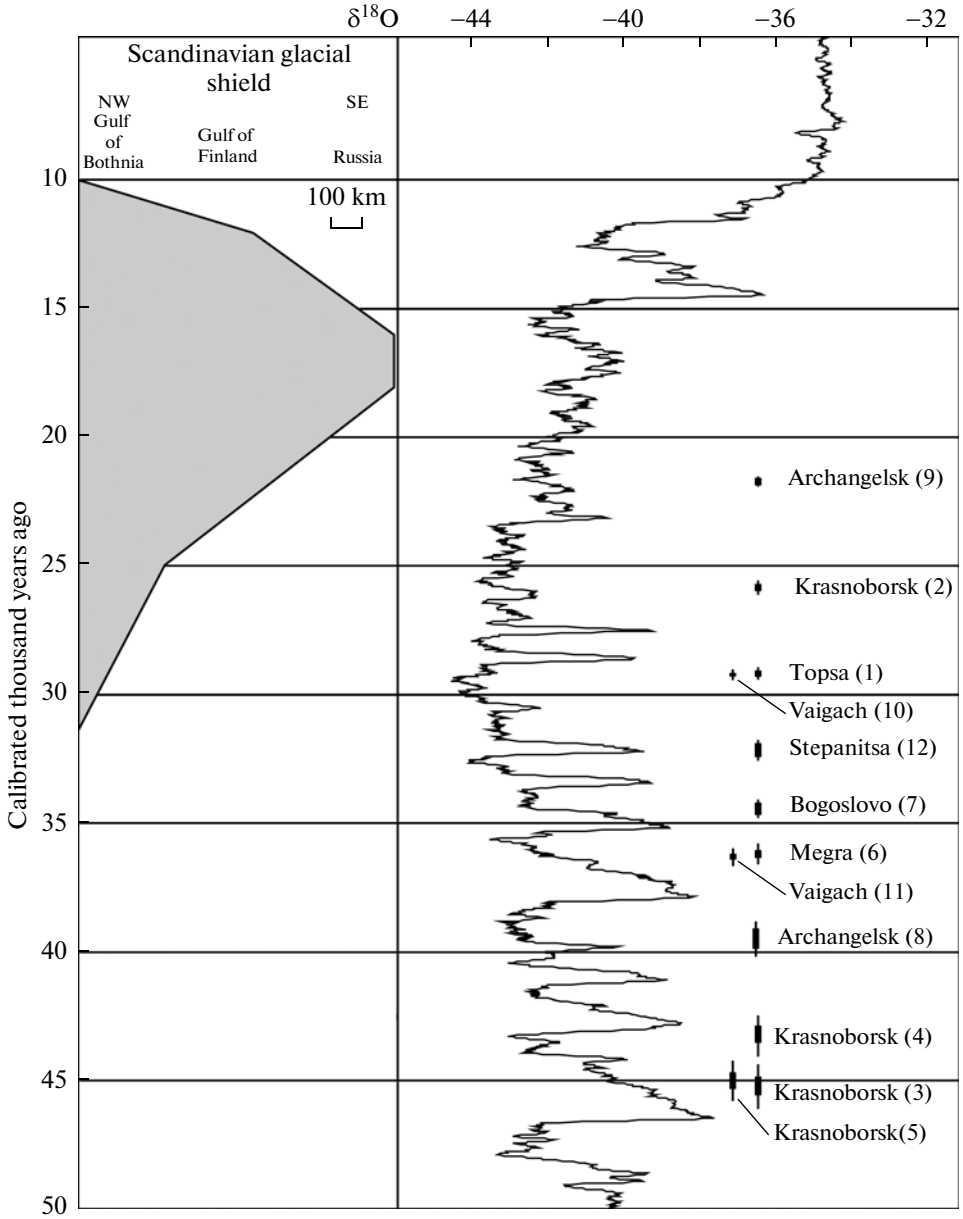

Fig. 2. Diagram displaying growth and degradation of the Scandinavian glacial shield in Finland and Russia [13] with a curve $\delta^{18}O$, according to the NGRIP data on the GICCO5 time scale [15]. 1950 is the zero year. Calibrated dates of the Quaternary mammal bone remains are shown on the right. Figures in brackets correspond to numbers in the table.

and later (relative to its southwestern part) advance of the Scandinavian glaciation in the region.

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