^{14}C DATABASE AND GEOGRAPHIC INFORMATION SYSTEM FOR WESTERN SIBERIA

LYOBOV A. ORLOVA,[1] YAROSLAV V. KUZMIN[2] and IVAN D. ZOLNIKOV[1]

ABSTRACT. We illustrate here the combined use of geographic information system (GIS) technology and a radiocarbon database for analysis of the environmental components and ancient sites in Western Siberia during the period 10–45 ka BP. In total, 230 ^{14}C dates from 75 Late Pleistocene outcrops and Paleolithic sites were used to generate paleolandscape maps and to establish the features of the spatiotemporal distribution of Paleolithic sites.

INTRODUCTION

We aim here to examine the interrelations between the natural environment and ancient people in the territory of Western Siberia from 10 to 45 ka BP, a period of rapid and severe environmental change throughout the Northern Hemisphere (*e.g.*, Wright 1983; Velichko 1984). Because Late Pleistocene and Early Holocene humans were hunter-gatherers, environmental conditions greatly affected the their lifestyle, economy and cultural development. The Late Pleistocene landscapes and climatic changes also influenced the peopling of different parts of Northern Asia. Western Siberia, including the southern part of the West Siberian Lowland and the Altai and Sayany Mountains, is a promising area for the study of human-environment interaction because a large body of data is available for both Quaternary geology and archaeology. Our radiocarbon database and geographic information system (GIS) technology for data processing and map generation are being used by scientists to establish a new approach for geoarchaeological research in Siberia.

The time interval under consideration, 10–45 ka BP, includes two major climato-stratigraphic subdivisions, the Karginian and Sartan horizons. The Karginian Interglacial has been ^{14}C dated between 50 and 23 ka BP (Kind 1974), and corresponds in general to the Middle Wisconsin Interglacial in North America. The Karginian period includes several warm intervals, such as an early warming at 45–50 ka BP, the Malaya Kheta warming/optimum, 35–41 ka BP, and the Lipovka-Novoselovo warming, 23–30 ka BP. The cold events are dated to 41 to 45 ka BP (the early cooling), and 30–35 ka BP (the Konoschelye cooling) (Arkhipov 1984; Arkhipov *et al.* 1986). The Sartan Glaciation dates to 10–23 ka BP and corresponds in general to the Late Wisconsin in North America.

METHODS

As sources of information, we use both our own data (Panychev 1979; Firsov, Panychev and Orlova 1985; Orlova and Panychev 1993; Orlova 1995) and the results published previously by other investigators (Tseitlin 1979; Arkhipov *et al.* 1980; Derevianko *et al.* 1990; Abramova *et al.* 1991; Derevianko and Markin 1992; Goebel 1993; Goebel, Derevianko and Petrin 1993; Arkhipov and Volkova 1994). The Western Siberian Radiocarbon Database, developed from 1995–1997, focuses on information about the environment and archaeological sites, divided into a "geological" and "archaeological" categories, respectively. Some "archaeological" data may be included in the "geological" category if they have paleoenvironmental information as well. In total, we collected 95 ^{14}C dates associated with natural environmental records from 36 Late Pleistocene outcrops, and 135 ^{14}C dates from 41 Paleolithic sites in Western Siberia (Figs. 1, 2; Appendix: Tables 3, 4).

[1]United Institute of Geology, Geophysics and Mineralogy, Siberian Branch of the Russian Academy of Sciences, Universitetsky Pr., 3, Novosibirsk 630090 Russia
[2]Pacific Institute of Geography, Far Eastern Branch of the Russian Academy of Sciences, Radio St. 7, Vladivostok 690041 Russia

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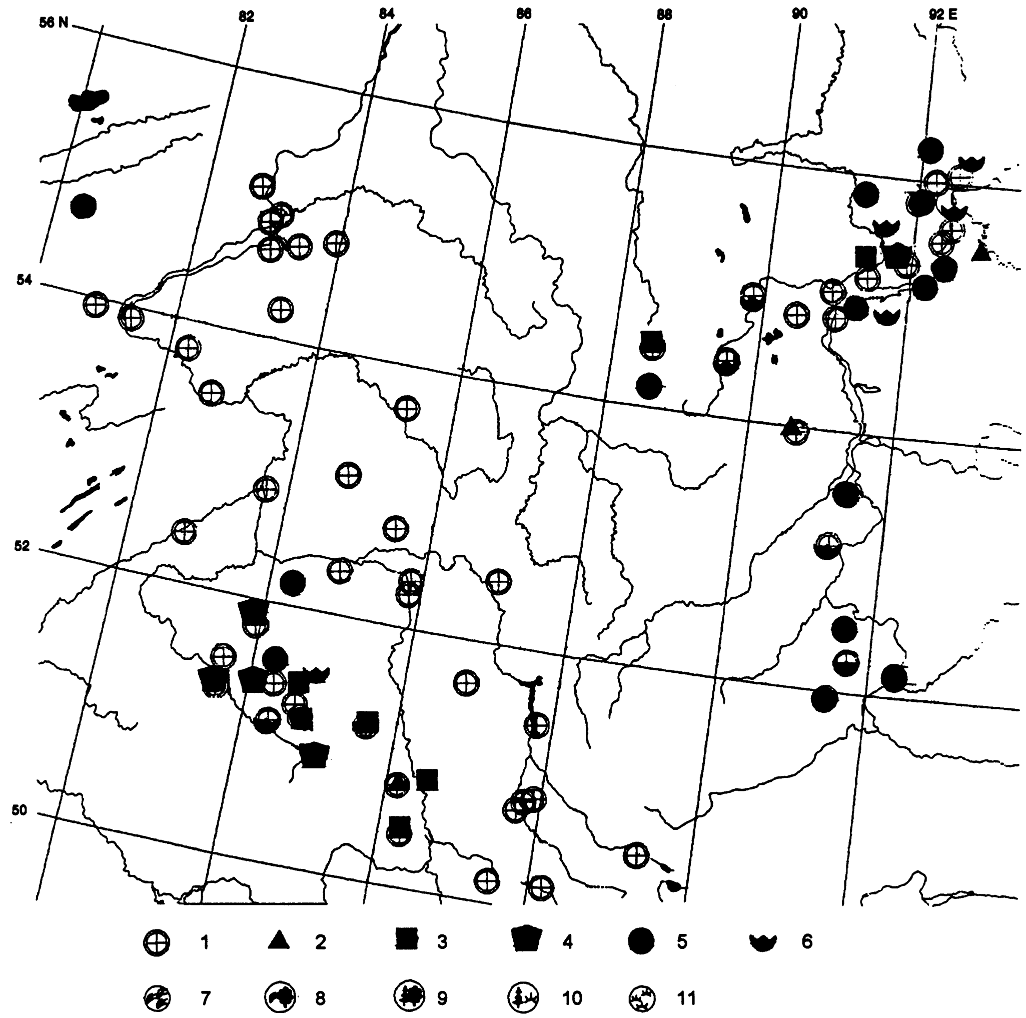

Fig. 1. Spatial distribution of the Paleolithic sites in Western Siberia and key to figure: 1. reference points (see Tables 3,4); 2. Early Karginian (42–55 ka BP) sites; 3. Middle Karginian (32–42 ka BP) sites; 4. Late Karginian (24–32 ka BP) sites, 5. Sartan (14–24 ka BP) sites; 6. Late Glacial (10–14 ka BP) sites; 7. steppe; 8. forest steppe; 9. taiga; 10. forest tundra; 11. tundra.

All reference points are assigned geographic coordinates and are placed on a chronological scale based on ^{14}C dates (Tables 3, 4). Each "geological" reference point is characterized by several kinds of information, separated into three blocks: 1) spatial coordinates, including latitude and longitude with degrees and minutes as decimal values, absolute elevation above sea level, and the depth below surface in the section; 2) a chronological component (*i.e.*, ^{14}C dates); and 3) paleoenvironmental information such as geomorphic features (*e.g.*, relief type, form and microfeatures), sediments (including data on lithology, stratigraphy, and the genesis of deposits), biotic features (vegetation type, faunal ecotype, and paleolandscape type), and paleoclimatic data (humidity and temperature) (Table 1). For "geological" points (Table 3), we combined the ^{14}C dates from each outcrop together, even if they belong to different strata. In the computer database, each ^{14}C date, or set of them, corresponds to a particular paleoenvironmental record subdivided into layers.

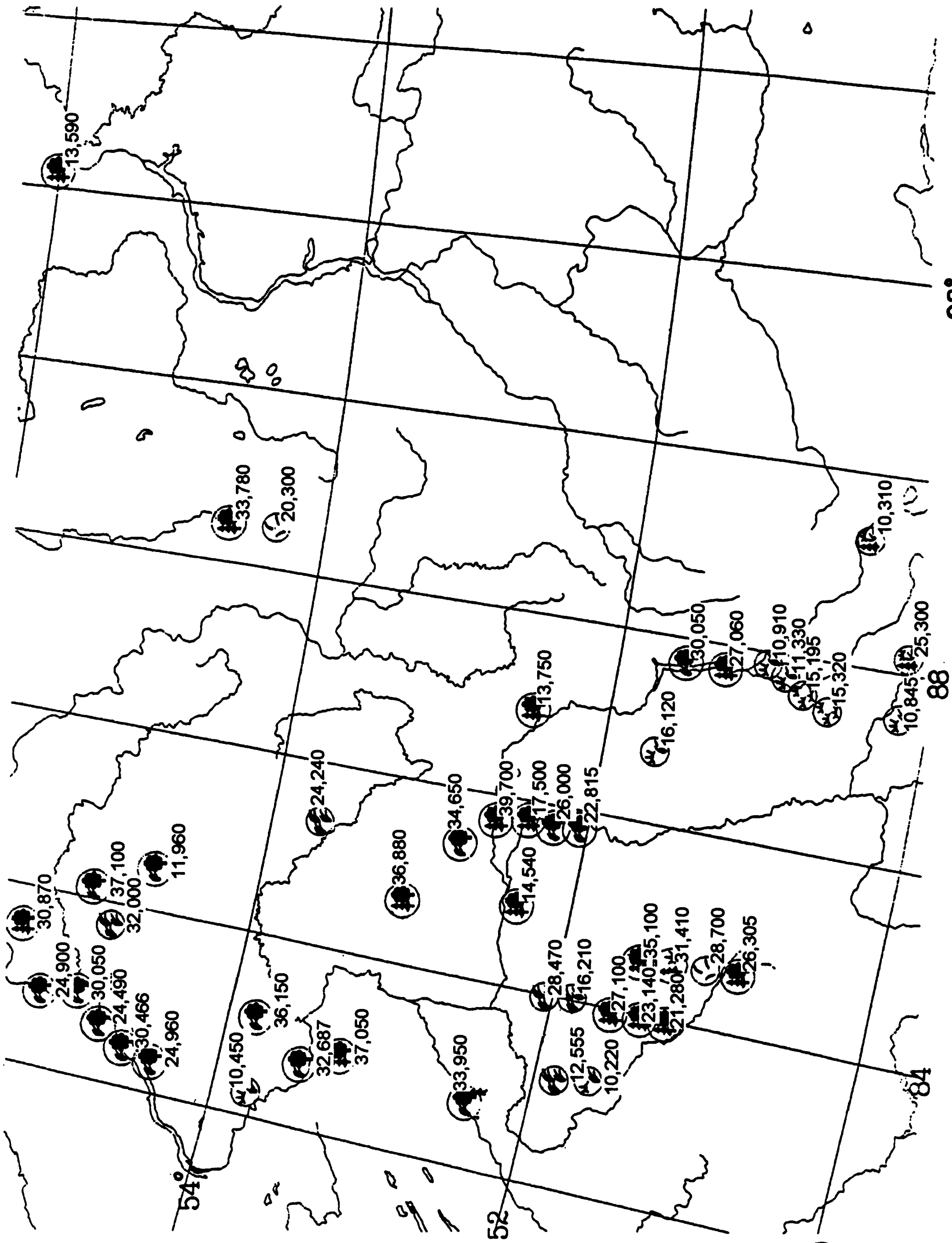

Fig. 2. Distribution of the reference points (paleoenvironmental and radiocarbon data) in Western Siberia

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TABLE 1. Features of Environment on Key Points

Name	Denisova Layer 21	***Typeages***		2.00 ***Amount 14C dates***	2.00

14C datenames	SOAN-2488, SOAN-2489

Weithmeanage	37,827.00	***Deviation***		***Maxage***	34,700.00	***Minage***	39,310.00

Longitude	84.70	***Latitude***	51.20	***Surfaceheight***	
Distancetop	3.20			***Insectioheight***	

Typerelief	***Formrelief***	***Elementrelief***
low-mountain	cave in original slope	central hall of cave
Code typerelief	***Code formrelief***	***Code elementrelief***

Lithology	***Stratigraphy***
dark-grey humic sandy loam	Karginskii

Frost process	***Genesis***	***Code of genes.***
	cave-dvelling deposits	

Vegetation type	***Veget.code***	***Fauna type***	***Fauna code***
sparse wood		mountain-steppe and silvan species	

Temperconditions	***Humidity***	***Paleolandscape***
near to modern		sparse wood
Tempercode	***Codehumidity***	***Paleolandscape code***

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TABLE 2. Archaeological Database

FEATURES OF HUMAN SITES		
Site name Denisova Layer 21		***Epoch*** Middle Palaeolith (Mousterian-Acheulian)
Exposition of slope SW	***Thickness of overlying deposits*** 3.20	
Lithology of underlying deposits yellow clay with rock debris and blocks ***Code of genesis of underlying deposits*** ***Genesis of underlying deposits*** cave-dwelling deposits		***Epoch code*** ***Culture code*** ***Culture*** Mousterian ***Traces of human activity*** hearth ***Material and raw material*** stone and bone
Code of genesis of overlying deposits ***Genesis of overlying deposits*** cave-dwelling deposits ***Lithology of overlying deposits*** light-brown dark grey sandy-loam		***Environmental peculiarities*** strategic position, cover, illumination (across natural well), nearness of water, lateral galleries

For "archaeological" points incorporated into the database, we added as characteristics the traces of human activity (*e.g.*, dwellings, fireplaces) and cultural affiliation (epoch and culture) (Table 2). All ^{14}C-dated archaeological sites were subdivided into five groups in terms of climatostratigraphy: 1) Early Karginian, 45–50 ka BP; 2) Middle Karginian, 30–33 BP; 3) Late Karginian, 24–30 ka BP; 4) Sartan, 15–20 ka BP; and 5) Late Glacial, 10–15 ka BP. The first group corresponds to the Mousterian, and the groups 3 through 5 belong to different stages of the Upper Paleolithic. Group 2 contains both terminal Mousterian and early Upper Paleolithic sites. There are two major geographic groups of ancient sites located quite far from each other, one in the Yenisei River basin and the other in the Altai Mountains foothills (Fig. 1).

To analyze the Late Pleistocene biotic and non-biotic environmental components and their influences on the spatial and temporal distribution of ancient sites, a Regional GIS Atlas was compiled. This Atlas is supported by several software packages, including GIS "ARC/INFO-ARCVIEW" (ESRI, Inc.), GIS "SOCRAT-GEO" (created at the Novosibirsk Regional Center for GISTechnologies, Siberian Branch of the Russian Academy of Sciences), and the Paradox® (Borland International, Inc.) database management system (DBMS). At the core of the GIS Atlas are the numerical and textual databases. The numerical database contains the morphological description and geographic position of the reference points, and this information may be processed by both ARC/INFO-ARC/VIEW and SOCRAT-GEO software. The textual database contains the information about the chronological, paleoenvironmental, and archaeological characteristics of the reference points, which are manipulated using the Paradox DBMS (Dementyev *et al.* 1997). The analytical functions of the GIS Atlas were executed through different types of requests to the Paradox DBMS, and the data processing results output on worksheets (Zabadaev and Zolnikov 1996). These results were combined with the numerical database to create computer maps within the GIS. The presentation of results is pictorial and easy to understand, allowing analysis of the data in many different combinations.

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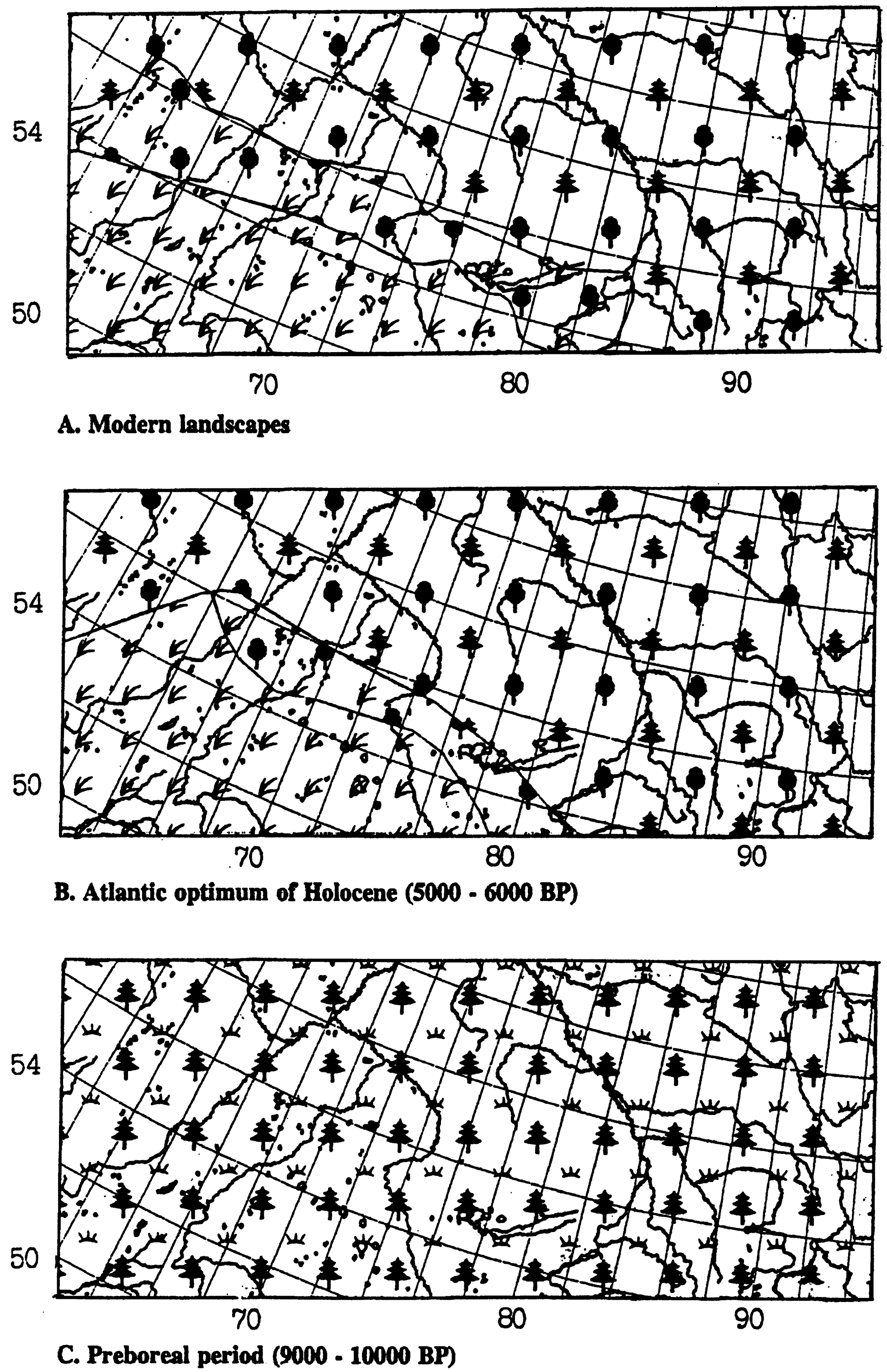

Fig. 3. Modern landscapes and the paleolandscape reconstruction for Western Siberia (10–45 ka BP). A. modern landscapes; B. Holocene Climatic Optimum (5–6 ka BP) landscapes; C. Preboreal period (9–10 ka BP) landscapes.

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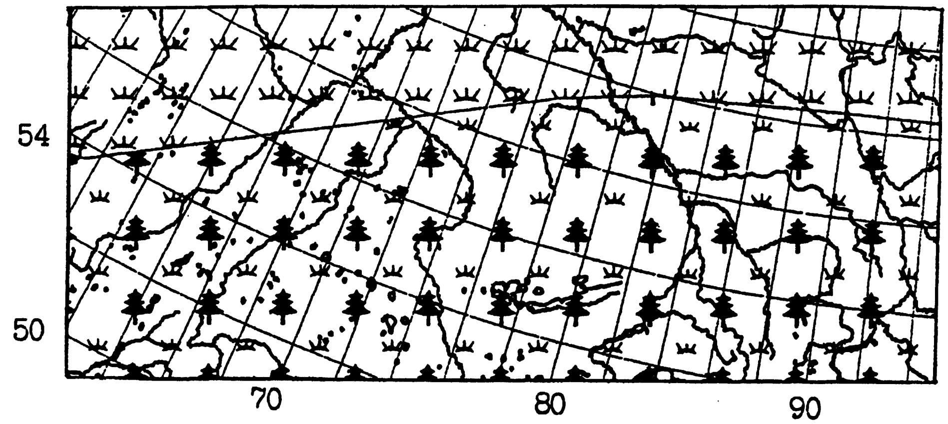
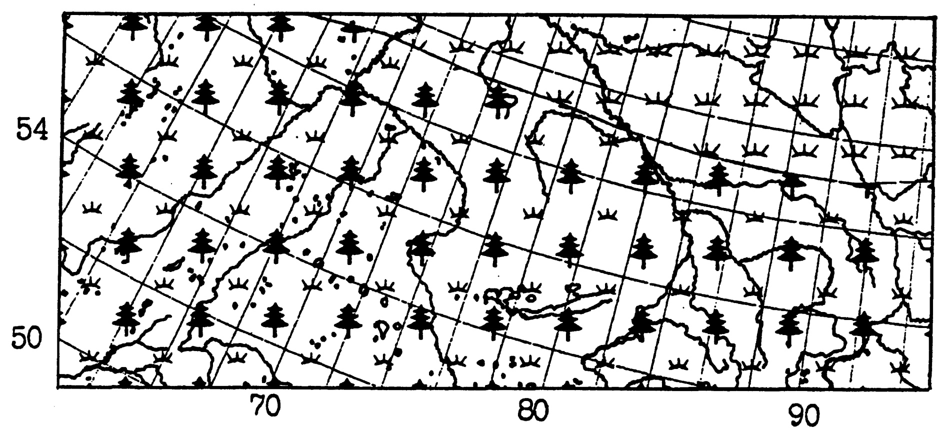
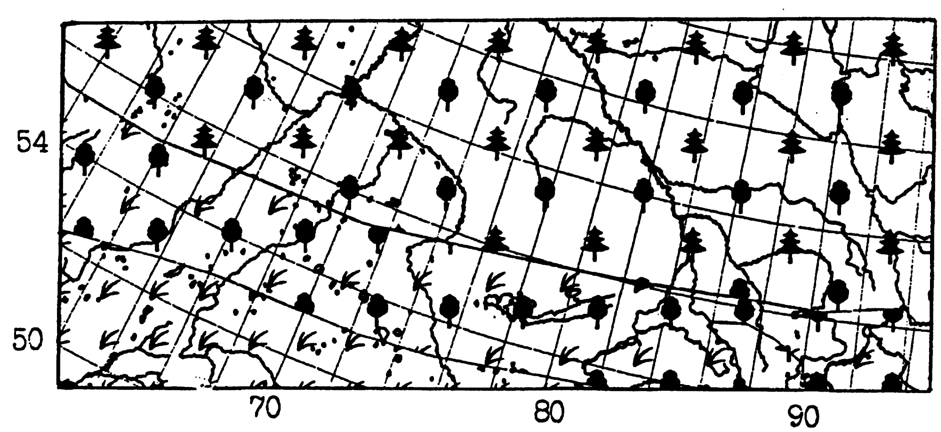


D. Sartan glaciation (18000 - 20000 BP)



E. Konoshelie cooling (30000 - 33000 BP)



F. Early Karginian warming (45000 - 50000 BP)

Fig. 3 (continued). D. Sartan Glaciation (18–20 ka BP) landscapes; E. Konoschelye cooling (30–32 ka BP); F. Early Karginian warming (45–50 ka BP).

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Results and Discussion

Using the Radiocarbon Database and GIS technology, maps of paleovegetation and ancient site distributions for several chronological intervals within the Karginian-Sartan period were generated. Maps of both modern landscapes and Holocene Climatic Optimum paleolandscapes, derived from published sources (Bukreeva *et al.* 1995; Arkhipov and Volkova 1994), are also presented (Fig. 3A,B). We present here the maps for the Early, Middle and Late Karginian, Sartan, and Late Glacial intervals (Fig. 3C–F).

Karginian Interglacial, 20–45 ka BP

For the Early Karginian, 45–50 ka BP, we have only a few ^{14}C-dated Paleolithic sites in the Altai Mountains, such as Kara-Bom and Okladnikov Cave. The paleolandscape reconstruction for this interval (Fig. 3, F), however, shows quite favorable climatic conditions for human occupation. The climate was even warmer than today, and similar to the Holocene Climatic Optimum (Fig. 3B). Despite this fact, we have only two ^{14}C-dated sites corresponding to the Early Karginian warming. Later, *ca*. 42–33 ka BP, the number of sites in the Altai increased slightly (these include Denisova Cave, Kara-Tenesh, and Malyi Yaloman) but the number of sites remains very low compared with the Late Karginian, 24–30 ka BP, when environmental conditions were similar. No ^{14}C-dated sites have been found in the Yenisei River basin for the Early Karginian period. This scarcity of the Mousterian and early Upper Paleolithic sites is probably due to the fact that this was the period of the initial human colonization of Western Siberia.

During the Middle Karginian period, 30–33 ka BP, the environmental conditions in Western Siberia were very unfavorable for human habitation. The vegetation in the vicinity of the Ust-Karakol 1 and 2 sites in the Altai foothills, dated to *ca*. 31,400 BP, consisted of a "cold steppe" and forest-tundra (Fig. 3, E). We have quite a few sites for this time interval in the Altai, such as Okladnikov Cave, Strashnaya Cave, Kara-Tenesh, Kara-Bom and Ust-Karakol 1-2. No Middle Karginian sites were found in the Yenisei River basin. The Malaya Syia site in the Sayany Mountains foothills, western Yenisei River basin, yielded three ^{14}C dates—20,300 BP, 33,060 BP and 34,500 BP (Table 4). The two oldest dates we consider less reliable because material dated was animal bone (Kuzmin and Tankersley 1996: 583). The most reliable ^{14}C date for this site is 20,300 ± 350 BP (SOAN-1124), from charcoal (Table 4).

In the Late Karginian, 24–30 ka BP, the conditions for human existence were more favorable than in the Middle Karginian. The vegetation cover during the occupation of the Okladnikov Cave, Strashnaya Cave, and Denisova Cave sites was characterized by steppe in the Altai piedmont zone and by taiga-like forests in the river valleys within the mountainous Altai. In the southern part of the West Siberian Lowland, the main vegetation type during the entire Late Karginian time period was forest-steppe and steppes. This landscape situation was almost identical to present (Fig. 3A). The first well-documented sites in the Yenisei River basin, such as Kurtak 4 (layers 11–12) and Kashtanka 1 (layer 1), date to the Late Karginian period.

Sartan Glaciation and Late Glacial, 10–20 ka BP

In the Sartan interval, 20–15 ka BP, the geographic distribution of ancient sites was quite different from that of the Late Karginian. There is a cluster of five sites in the Yenisei River valley, and there are a few sites in the southern West Siberian Lowland (Mogochino and Tomsk). The concentration of sites in the Yenisei valley may be explained by comparatively favorable environmental conditions

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at this time. Evidence of severe environment, such as "cold steppe" vegetation, is known in the Yenisei valley only for the maximal Sartan climatic deterioration, *ca.* 20 ka BP (Fig. 3D). Within the interval 19,300–14,750 BP, the main vegetation types were forest-steppes in the upper Yenisei River and taiga in the lower part of the Yenisei basin to the north (Kind 1974).

In the Altai Mountains and the southern West Siberian Lowland, during all of the Sartan period and in most of Late Glacial (12–20 ka BP), the vegetation was mostly forest-tundra and tundra (Fig. 3D). Both taiga and forest-steppe have survived as separate "islands". The distinct feature for this time interval is the absence of Paleolithic sites in the Altai Mountains and their foothills. Human occupation of the Volchiya Griva and Chernoozerie sites *ca.* 14,200–14,500 BP probably correlates with the general climatic amelioration shortly after 15 ka BP and the rather favorable environmental situation in the southern part of the West Siberian Lowland, compared with Altai Mountains.

In the Late Glacial, 10–15 ka BP, the environmental situation in the Yenisei River basin was quite favorable for human existence. Here we have a cluster of *ca.* 17 ^{14}C-dated Late Paleolithic sites (Table 4). The main vegetation type near the Maininskaya (Layers 1–4), Tashtyk 1 (Layer 1), and the Bolshoi Kemchug sites was pine and pine-birch forest with an admixture of dwarf birch. In the Altai region, however, the vegetation in the vicinity of Kaminnaya and Denisova Caves between 9300 and 11,900 BP was mostly tundra-steppe (or "cold steppe"). The paleolandscape reconstruction for the Pleistocene-to-Holocene transition in Western Siberia (Fig. 3C) shows that in Preboreal times, *ca.* 9–10 ka BP, entire area south from 64°N was covered by forest-tundra, whereas the area north of 64°N was occupied by tundra.

The Dynamics of Human Colonization of Western Siberia

Using the most updated information on the spatiotemporal distribution of the Paleolithic sites, it is possible to establish the general features of the human settlement of Western Siberia. It seems that the first human settlements appeared in the Altai Mountains *ca.* 42,500–46,000 BP, as shown by Okladnikov Cave and Kara-Bom. There is one Mousterian site known in the western part of Yenisei River basin, Dvuglazka Cave (Abramova 1989), without ^{14}C determinations. In the Altai region, the earliest Upper Paleolithic sites such as Kara-Bom (Layer 2 a-b), Kara-Tenesh, and Malyi Yaloman, very probably coexisted with the latest Mousterian sites during the time interval of *ca.* 33–43 ka BP (Table 4). It is quite clear that in Western Siberia we have "overlapping" in ^{14}C chronologies for the Mousterian and early Upper Paleolithic, rather than the very early (pre-43 ka BP) Middle-to-Upper Paleolithic transition suggested by Goebel (1993).

In the Yenisei River basin, the first well-documented evidence of human occupation known so far is from the Kurtak 4 site, ^{14}C-dated to *ca.* 27,500 BP. After this time we have evidence of a permanent human presence in the Yenisei River basin. In the Altai and Sayany Mountains, however, there is a marked *gap* in the sequence of dates from the Upper Paleolithic sites from *ca.* 20 ka BP to *ca.* 12 ka BP. This probably reflects the unfavorable natural environment for human occupation during this time in the foothills and intramontane areas of the heavily glaciated Altai Mountains (Serebryanny 1984; Arkhipov *et al.* 1986). After *ca.* 12 ka BP, human populations returned to the Altai and Sayany Mountains

Conclusion

This paper illustrates the application of a Radiocarbon Database and GIS technology for the analysis of both natural environments and ancient site distributions. The employment of a GIS Atlas allows us to create maps of the paleoenvironment for different time intervals. Data on the spatiotemporal distribution of Paleolithic sites can then be superimposed on the paleoenvironmental maps. The simultaneous analysis of both kinds of information helps to reveal the peculiarities of human existence in the natural environments of Pleistocene Western Siberia. In the near future, similar research will be carried out for the entire territory of Siberia and the Russian Far East.

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References

Abramova, Z. A. 1989 The Paleolithic of Northern Asia. *In* Boriskovsky, P. I., ed., *The Paleolithic of Caucasus and Northern Asia*. Leningrad, Nauka: 145–243 (in Russian).

Abramova, Z. A., Astakhov, S. N., Vasiliev, S. A., Ermolova, N. M. and Lisitsyn, N. F. 1991 *The Paleolithic of Yenisei*. Leningrad, Nauka Publishers: 159 p. (in Russian).

Arkhipov, S. A. 1984 Late Pleistocene Glaciation of Western Siberia. *In* Velichko, A. A., ed., *Late Quaternary Environments of the Soviet Union*. Minneapolis, University of Minnesota Press: 13–19.

Arkhipov, S. A., Astakhov, V. I., Volkov, I. A., Volkova, V. S. and Panychev, V. A. 1980 *Paleogeography of Western Siberian Plain at the Late Zyryanka Glaciation Maximum*. Novosibirsk, Nauka Publishers: 110 p. (in Russian).

Arkhipov, S. A., Isayeva, L. L., Bespaly, V. G. and Glushkova, O. Y. 1986 Glaciation of Siberia and Northeast USSR. *In* Sibrava, V., Bowen, D. Q. and Richmond, G. M., eds., Quaternary Glaciations in the Northern Hemisphere. *Quaternary Science Reviews* 5: 463–474.

Arkhipov, S. A. and Volkova, V. S. 1994 *Geological History, Pleistocene Landscapes and Climate in West Siberia*. Novosibirsk, United Institute of Geology, Geophysics and Mineralogy Press: 105 p. (in Russian).

Bukreeva, G. F., Arkhipov, S. A., Volkova, V. S. and Orlova, L. A. 1995 Climate of Western Siberia: Past and future. *Geology and Geophysics* 36(11): 3–22 (in Russian).

Dementyev, V. N., Dobretsov, N. N., Zabadaev, L. S., Zolnikov, L. D. and Patrenina, M. A. 1997 Spatial data semantic in geoinformation modeling of complex objects and structures. *GIS for Environmentally Sustainable Development*. Proceedings of the International Conference "Intercarto 3". Novosibirsk: United Institute of Geology, Geophysics and Mineralogy Press: 220–230 (in Russian).

Derevianko, A. P., Grichan, Y. V., Dergacheva, M. I., Zenin, A. N., Laukhin, S. A., Levkovskaya, G. M., Maloletko, A. M., Markin, S. V., Molodin, V. I, Ovodov, N. D., Petrin, V. T. and Shunkov, M. V. 1990 *Archaeology and Paleoecology of the Paleolithic of Mountainous Altai*. Novosibirsk, Institute of Archaeology and Ethnography Press: 159 p. (in Russian).

Derevianko, A. P. and Markin, S. V. 1992 *The Mousterian of Mountainous Altai*. Novosibirsk, Nauka Publishers: 224 p. (in Russian).

Firsov, L. V., Panychev, V. A. and Orlova, L. A. 1985 *The Catalogue of Radiocarbon Dates*. Novosibirsk, United Institute of Geology, Geophysics and Mineralogy Press: 88 p. (in Russian).

Goebel, T. (ms.) 1993 The Middle to Upper Paleolithic transition in Siberia. Ph.D. dissertation, The University of Alaska, Fairbanks: 382 p.

Goebel, T., Derevianko, A. P. and Petrin, V. T. 1993 Dating the Middle-to-Upper Paleolithic Transition at Kara-Bom. *Current Anthropology* 34: 452–458.

Kind, N. V. 1974 Geochronology of the Late Anthropogene according to isotopic data. *Proceedings of the Geological Institute, USSR Academy of Sciences* 275: 1–274 (in Russian).

Kuzmin, Y. V. and Tankersley, K. B. 1996 The colonization of Eastern Siberia: An evaluation of the Paleolithic age radiocarbon dates. *Journal of Archaeological Science* 23: 577–585.

Orlova, L. A. 1995 Radiocarbon dating of archaeological sites from Siberia and the Russian Far East. *In* Derevianko, A. P. and Kholushkin, Y. P., eds., *Methods of Natural Sciences in Archaeological Reconstructions*. Novosibirsk, Institute of Archaeology and Ethnography Press: 207–232 (in Russian).

Orlova, L. A. and Panychev, V. A. 1993 The reliability of radiocarbon dating buried soils. *Radiocarbon* 35(3): 369–377.

Panychev, V. A. 1979 *Radiocarbon Chronology of the Altai Piedmont Plain Alluvial Deposits*. Novosibirsk, Nauka Publishers: 104 p. (in Russian).

Serebryanny, L. R. 1984 Mountain glaciation in the USSR in the Late Pleistocene and Holocene. *In* Velichko, A. A., ed., *Late Quaternary Environments of the Soviet Union*. Minneapolis, University of Minnesota Press: 45–54.

Tseitlin, S. M. 1979 *Geology of the Paleolithic of Northern Asia*. Moscow, Nauka Publishers: 285 p. (in Russian).

Velichko, A. A., ed. 1984 *Late Quaternary Environments of the Soviet Union*. Minneapolis, University of Minnesota Press: 327 p.

Wright, H. E., Jr., ed. 1983 Late Quaternary Environments of the United States, Vol. 1. *In* Porter, S. C., ed. *The Late Pleistocene*. Minneapolis, University of Minnesota Press: 407 p.

Zabadaev, I. S. and Zolnikov, I. D. 1996 Representation of subdefinite spatial objects in geological GIS. Proceedings of the 2nd Joint European GIS-Conference, Barcelona, Spain, March 27–29, 1996. Vol. 1. Barcelona, University of Barcelona Press: 547–554

APPENDIX

TABLE 3. ^{14}C Dates for the Late Quaternary Sections in Western Siberia

Section name	Lat. (°N)	Long. (°E)	^{14}C date (yr BP)	Sample no.*	Material
Western Siberian Lowland					
Taradanov	53.77	81.83	35,050 ± 450	SOAN-1069	Wood
			38,850 ± 2200	SOAN-1069G	Humates
Iskitimskaya	54.63	83.37	33,100 ± 1600	SOAN-165	Charcoal
Lower soil			32,780 ± 670	SOAN-629	Bone
Lower soil			29,000 ± 450	IGAN-168	Humates
Upper soil			26,300 ± 700	IGAN-167	Humates
Kargapolovo	53.70	81.95	32,400 ± 2000	SOAN-23	Plant detritus
			33,450 ± 550	SOAN-744	Plant detritus
			32,275 ± 420	SOAN-1254	Plant detritus
Ogurtsovo	54.85	83.00	>34,360	SOAN-1586	Charcoal
			30,050 ± 850	SOAN-1587	Charcoal
			24,490 ± 320	SOAN-1623	Charcoal
Mamonovo	54.47	84.09	11,100 ± 330	SOAN-112	Wood
			12,450 ± 55	SOAN-411	Wood
			12,820 ± 495	SOAN-11	Peat
			37,100 ± 2000	SOAN-10	Wood
Kytmanovo	53.45	85.43	24,240 ± 2700	SOAN-31	Plant detritus
Malyshevo	53.73	82.07	40,450 ± 1000	SOAN-1632	Wood
			35,350 ± 470	SOAN-1633	
Nizhni Suzun	53.72	82.15	12,140 ± 50	SOAN-2152	Plant detritus
			10,450 ± 50	SOAN-2153	Plant detritus
			33,600 ± 2400	SOAN-29	Wood
			36,600 ± 310	SOAN-741	Wood
			28,000 ± 620	SOAN-30	Wood
			12,660 ± 130	SOAN-1638	Peat
			10,950 ± 150	SOAN-54	Peat
			12,050 ± 50	SOAN-2148	Peat
			12,640 ± 50	SOAN-2149	Peat

TABLE 3. ^{14}C Dates for the Late Quaternary Sections in Western Siberia *(Continued)*

Section name	Lat. (°N)	Long. (°E)	^{14}C date (yr BP)	Sample no.*	Material
Verkhnii Suzun	53.72	82.15	39,400 ± 1100	SOAN-737	Wood
			35,300 ± 800	SOAN-738	Wood
			46,100 ± 2300	SOAN-1636	Wood
			28,800 ± 310	SOAN-740	Wood
			26,650 ± 200	SOAN-739	Wood
			26,800 ± 200	SOAN-1637	Wood
Novy Syrt	52.25	85.98	39,900 ± 3100	SOAN-53	Wood
			39,600 ± 1200	SOAN-748	Wood
			17,500 ± 100	SOAN-746	Peat
			35,400 ± 700	SOAN-747	Plant detritus
			15,850 ± 680	LG-14	Peat
Anuiskoe	52.29	84.82	14,540 ± 365	SOAN-16	Plant detritus
			13,600 ± 120	SOAN-69	Plant detritus
Bolshaya Rechka	53.03	84.80	35,980 ± 720	SOAN-436	Wood
			37,340 ± 660	SOAN-1258	Wood
			24,750 ± 300	SOAN-152	Wood
			24,870 ± 260	SOAN-153	Wood
			25,970 ± 180	SOAN-1257	Wood
			27,900 ± 600	LG-68	Wood
			23,300 ± 200	SOAN-39	Wood
			23,080 ± 190	SOAN-154	Wood
Kalistratikha	52.53	83.38	32,270 ± 500	SOAN-396	Wood
			31,000 ± 600	MGU-203	Wood
Bobkovo	52.47	82.75	21,700 ± 900	SOAN-446	Plant detritus
Koinihinskoye	54.02	81.53	21,700 ± 900	SOAN-12	Humates
			19,550 ± 900	SOAN-164	Humates
Bekhtemirka	52.34	83.24	19,480 ± 300	SOAN-76	Humates
Krasnyi Yar	55.13	82.83	29,410 ± 250	SOAN-1456	Wood
			29,640 ± 2750	SOAN-15	Wood
			28,600 ± 340	SOAN-1065G	Wood
			30,870 ± 300	SOAN-1457	Wood
			33,060 ± 1030	SOAN-1458	Wood
			32,930 ± 1540	BashGI-52	Plant detritus
			41,530 ± 1650	SOAN-1459	Wood
Volchii Log	52.67	85.67	34,650±2100	SOAN-161	Peat
Srostki	52.17	85.72	25,140 ± 170	SOAN-2405	Wood
			25,030 ± 380	SOAN-2405A	Wood
			24,800 ± 200	SOAN-2405B	Humates
			26,090 ± 180	SOAN-2406	Wood
			26,700 ± 140	SOAN-2407A	Wood
			25,300 ± 400	SOAN-2407B	Humates
			25,815 ± 160	SOAN-2408	Gyttja

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TABLE 3. ^{14}C Dates for the Late Quaternary Sections in Western Siberia *(Continued)*

Section name	Lat. (°N)	Long. (°E)	^{14}C date (yr BP)	Sample no.*	Material
Belovo	54.03	83.17	23,160 ± 550	SOAN-2499	Humates
Baryshevo	54.04	83.91	24,900 ± 380	IGAN-199	Humates
Kozyulino	56.50	84.99	44,700 ± 2300	SOAN-334	Peat
			44,990 ± 2100	SOAN-335	Peat
Altai Mountains					
Bele 1	51.42	87.78	30,050 ± 435	SOAN-2725	Charcoal
			27,060 ± 850	SOAN-3119	Carbonates
Bele 2	51.42	87.78	11,450 ± 145	SOAN-3118	Carbonates
Elinovo	51.31	83.24	20,100 ± 240	SOAN-2872	Mollusk shells
Karakudur	50.65	87.75	11,840 ± 100	SOAN-2185	Carbonates
			10,650 ± 110	SOAN-2186	Carbonates
			10,820 ± 100	SOAN-2101	Mollusk shells
			15,195 ± 65	SOAN-2100	Carbonates
Rakhomysty	50.50	88.17	42,080 ± 1675	SOAN-2102A	Gyttja
Kuekhtanar	50.15	88.32	40,870 ± 1255	SOAN-2383	Gyttja
Eshtykhkol	50.20	87.73	10,845 ± 80	SOAN-2346	Plant detritus
Kubadru	50.58	87.87	15,320 ± 105	SOAN-2187	Carbonates
Tabunka	51.42	83.36	10,220 ± 90	SOAN-2599	Mollusk shells
			12,555 ± 55	SOAN-2598	Wood
			13,945 ± 50	SOAN-2597	Plant detritus
Bashkaus	50.75	87.82	10,910 ± 70	SOAN-2089	Charcoal
Bogoyash	50.47	89.47	10,310 ± 90	SOAN-2705	Plant detritus
Lozhok	54.80	83.09	30,000 ± 1000	IGAN-169	Humates
Turochak	52.25	87.12	13,750 ± 70	SOAN-576	Wood
Bolshoye Eniseiskoye	52.66	85.67	26,200 ± 620	SOAN-51	Wood
			25,900 ± 340	SOAN-52	Wood

*Lab codes: SOAN=Institute of Geology and Geophysics; IGAN=Institute of Geography; LG=All-Union Research Geological Institute, Leningrad (inactive); BashGI=Geological Institute of the Bashkirian Scientific Center, Ufa (inactive); MGU=Moscow State University.

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TABLE 4. ^{14}C Dates for the Paleolithic Sections in Western Siberia

Site name Layer	Lat. (°N)	Long. (°E)	^{14}C date (yr BP)	Sample no.*	Material
Western Siberian Lowland					
Mogochino	57.75	83.52	20,150 ± 240	SOAN-1513	Bone
Tomsk	56.48	84.92	18,300 ± 1000	GIN-2100	Charcoal
Volchiya Griva	54.63	80.25	14,450 ± 110	SOAN-111	Bone
			14,200 ± 150	SOAN-78	Bone
Cheroozierye 2	56.23	73.50			
Layer 2			14,500 ± 500	GIN-622	Charcoal
Altai Mountains					
Okladnikov Cave	51.67	84.00			
Layer 1			43,300 ± 1500	RIDDL-722	Bone
Layer 3			40,700 ± 1100	RIDDL-720	Bone
Layer 3			32,400 ± 500	RIDDL-721	Bone
Layer 2			37,750 ± 750	RIDDL-719	Bone
Layer 1			33,500 ± 700	RIDDL-718	Bone
Layer 1			>16,210	SOAN-2458	Bone
Layer 1			28,470 ± 1250	SOAN-2459	Bone
Strashnaya Cave	51.75	83.84	>25,000	SOAN-785	Bone
			31,510 ± 2615	SOAN-3219	Bone
Denisova Cave	51.20	84.70			
Layer 21			>34,700	SOAN-2488	Humates
Layer 21			39,390 ± 1310	SOAN-2489	Humates
Layer 11			>37,235	SOAN-2504	Bone
Kara-Bom	50.10	86.40			
Layer 2a			43,200 ± 1500	GX-17597	Charcoal
Layer 2b			43,300 ± 1600	GX-17596	Charcoal
Layer 2b			33,800 ± 600	GIN-5935	Charcoal
Layer 2c			34,180 ± 640	GX-17595	Charcoal
Layer 2c			33,780 ± 570	GX-17594	Charcoal
Layer 2c(?)			32,000 ± 600	GIN-5934	Bone
Layer 2d			38,080 ± 910	GX-17592	Charcoal
Layer 2d			30,990 ± 460	GX-17593	Charcoal
Kara-Tenesh	50.10	85.90	42,165 ± 4170	SOAN-2485	Charcoal
			31,400 ± 410	SOAN-1160	Bone
Malyi Yaloman	49.80	86.30	33,350 ± 1145	SOAN-2500	Charcoal
Ust-Karakol 1	51.10	84.70			
Layer 6			29,860 ± 355	SOAN-3358	Charcoal
Layer 6			29,720 ± 360	SOAN-3359	Charcoal
Layer 5			31,410 ± 1160	SOAN-2515	Charcoal
Layer 5			31,345 ± 1275	SOAN-2869	Charcoal
Layer 5			30,460 ± 2035	SOAN-3260	Charcoal
Layer 5			29,900 ± 2070	IGAN-837	Charcoal
Layer 4			26,305 ± 280	SOAN-3261	Charcoal

TABLE 4. ^{14}C Dates for the Paleolithic Sections in Western Siberia *(Continued)*

Site name Layer	Lat. (°N)	Long. (°E)	^{14}C date (yr BP)	Sample no.*	Material
Layer 4			27,020 ± 435	SOAN-3356	Charcoal
Layer 4			26,920 ± 310	SOAN-3357	Charcoal
Layer 4			26,920 ± 310	SOAN-3356	Humates
Layer 3			33,400 ± 1285	SOAN-3257	Charcoal
Layer 2			28,700 ± 850	SOAN-2614	Bone
Ust-Karakol 2					
Layer 5			31,430 ± 1180	IGAN-1077	Bone
Anyi 2	51.30	84.60			
Layer 12			26,810 ± 290	SOAN-3005	Charcoal
Layer 8			24,205 ± 420	SOAN-3006	Charcoal
Layer 3 (4?)			27,125 ± 580	SOAN-2868	Charcoal
Layer 3			21,280 ± 440	SOAN-3007	Charcoal
Layer 3			20,350 ± 290	SOAN-2863	Charcoal
Layer 3			22,610 ± 140	SOAN-2862	Charcoal
Denisova Cave, pit	51.20	84.70	10,800 ± 40	SOAN-2865	Charcoal
			10,690 ± 65	SOAN-2866	Charcoal
Kaminnaya Cave	50.90	84.30			
Layer A			11,900 ± 140	SOAN-2551	Charcoal
Layer A2			9335 ± 190	SOAN-2553	Charcoal
Layer 11			10,310 ± 330	SOAN-3402	Charcoal
Sayany Mountains					
Mokhovo 2	54.40	86.60	30,330 ± 445	SOAN-2861	Bone
Shestakovo	55.64	88.00	20,770 ± 560	SOAN-3218	Bone
Malaya Syia	54.50	89.42	20,300 ± 350	SOAN-1124	Charcoal
			33,060 ± 300	SOAN-1287	Bone
			34,500 ± 450	SOAN-1286	Bone
Bolshoi Kemchug	54.45	89.50	10,980 ± 55	SOAN-1125	Charcoal
			10,890 ± 60	SOAN-1126	Charcoal
Yenisei River basin					
Kurtak 4	55.17	91.58			
Layers 11–12			27,470 ± 200	LE-2833	Charcoal
Layer 11			24,890 ± 670	LE-3357	Bone
Layer 11			24,800 ± 400	GIN-5350	Charcoal
Layer 11			24,170 ± 230	LE-3351	Charcoal
Layer 11			24,000 ± 2950	LE-4156	Bone
Layer 11			23,800 ± 900	LE-4155	Charcoal
Layer 11			23,470 ± 200	LE-2833a	Charcoal
Kashtanka 1	55.13	91.42			
Layer 1			24,805 ± 425	SOAN-2853	Charcoal
Layer 1			24,400 ± 1500	IGAN-1048	Charcoal
Layer 1			23,830 ± 850	IGAN-1050	Charcoal
Layer 2			21,800 ± 200	IGAN-1049	Charcoal
Layer 2			20,800 ± 600	GIN-6968	Charcoal

TABLE 4. ^{14}C Dates for the Paleolithic Sections in Western Siberia *(Continued)*

Site name Layer	Lat. (°N)	Long. (°E)	^{14}C date (yr BP)	Sample no.*	Material
Ui 1	52.93	91.50			
Layer 2			22,830 ± 530	LE-4189	Charcoal
Layer 2			19,280 ± 200	LE-4257	Bone
Layer 2			17,520 ± 130	LE-3359	Bone
Layer 2			16,760 ± 120	LE-3358	Bone
Novoselovo 13	55.08	91.00			
Layer 3			22,000 ± 700	LE-3739	Charcoal
Afontova Gora 2	56.00	92.75	20,900 ± 300	GIN-117	Charcoal
			11,330 ± 270	Mo-343	Charcoal
Layer 5			15,130 ± 795	SOAN-3251	Bone
Layer 4			14,070 ± 110	SOAN-3075	Bone
Layer 3			14,330 ± 95	SOAN-3077	Bone
Shlenka	55.20	92.05	20,100 ± 300	GIN-3017	Bone
Nizhny Idzhyr 1	52.08	92.33	17,200 ± 140	LE-1984	Charcoal
Mayninskaya	52.22	91.50			
Layer B			15,200 ± 150	LE-2383	Charcoal
Layer A-1			12,110 ± 220	LE4255	Bone
Layer A			11,700 ± 100	LE-3019	Charcoal
Layer 5			16,540 ± 170	LE-2135	Bone
Layer 4			13,690 ± 390	LE-4251	Bone
Layer 4			12,910 ± 100	LE-2133	Bone
Layer 3			12,330 ± 150	LE-2149	Bone
Layer 3			12,120 ± 650	LE-4252	Bone
Layer 2-2			10,800 ± 200	LE-2378	Charcoal
Layer 2-1			12,120 ± 220	LE-2300	Bone
Layer 1			15,500 ± 150	LE-2299	Bone
Kurtak 3	55.17	91.58			
Pit 1			16,900 ± 700	GIN-2102	Charcoal
Pit 1			14,390 ± 100	LE-1456	Charcoal
Pit 2			14,600 ± 200	GIN-2101	Charcoal
Pit 2			14,300 ± 100	LE-1457	Charcoal
Novoselovo 7	55.07	91.00	15,000 ± 300	GIN402	Charcoal
Kokorevo 4a	54.83	90.92			
Layer 2			15,460 ± 320	LE-540	Charcoal
Kokorevo 4	54.83	90.92			
Layers 3–5			14,320 ± 330	LE-469	Charcoal
Kokorevo 1	54.83	90.92			
Layer 3			15,900 ± 250	IGAN-104	Charcoal
Layer 3			14,450 ± 150	LE-628	Charcoal
Layer 3			13,300 ± 50	GIN-91	Charcoal
Layer 3			13,000 ± 500	IGAN-102	Bone
Layer 2			15,200 ± 200	IGAN-105	Charcoal
Layer 2			13,100 ± 500	IGAN-103	Bone
Layer 2			12,940 ± 270	LE-526	Charcoal

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TABLE 4. ^{14}C Dates for the Paleolithic Sections in Western Siberia *(Continued)*

Site name Layer	Lat. (°N)	Long. (°E)	^{14}C date (yr BP)	Sample no.*	Material
Oznachennoye 1	53.10	91.50	15,020 ± 150	LE-1404	Bone
Tashtyik 4	54.70	90.85	14,700 ± 150	GIN-262	Charcoal
Listvenka	55.92	92.33			
Layer 8			12,750 ± 140	IGAN-1078	Charcoal
Layer 7			14,750 ± 250	GIN-6092	Charcoal
Layer 6			13,590 ± 350	IGAN-1079	Charcoal
			13,850 ± 485	SOAN-3463	Charcoal
Golubaya 1	53.00	91.50			
Layer 3			13,650 ± 180	LE-1101d	Bone
			13,050 ± 90	LE-1101a	Charcoal
			12,980 ± 140	LE-1101c	Bone
			12,900 ± 150	LE-1101b	Bone
Kokorevo 2	54.83	90.92	13,300 ± 100	GIN-90	Charcoal
Bolshaya Slizneva	55.95	92.30			
Layer 8			13,540 ± 500	SOAN-3315	Charcoal
Layer 7			12,930 ± 60	SOAN-3009	Bone
Kokorevo 3	54.83	90.92	12,690 ± 140	LE-629	Charcoal
Tashtyik 1, Layer 1	54.70	90.85	12,180 ± 120	LE-771	Charcoal
Eleneva Cave, pit	55.93	92.30	13,665 ± 90	SOAN-3333	Bone
Layer 21			10,380 ± 85	SOAN-3255	Bone
Layer 20			10,460 ± 95	SOAN-3254	Bone
Layer 19			11,250 ± 335	SOAN-3253	Bone
Layer 18			12,040 ± 150	SOAN-3252	Bone
Layers 16–17			10,485 ± 310	SOAN-2948	Charcoal
Paleolithic					
Layer 1			12,050 ± 325	SOAN-3307	Charcoal
Layer 1			12,040 ± 160	SOAN-3308	Charcoal
Layer 1			12,085 ± 105	SOAN-3309	Charcoal
Layer 1			11,430 ± 115	SOAN-3310	Charcoal
Paleolithic					
Layer 2			13,665 ± 90	SOAN-3333	Bone
Novoselovo 6	54.70	90.85	11,600 ± 500	GIN-403	Charcoal

*Lab codes: SOAN=Institute of Geology and Geophysics; GIN=Geological Institute; RIDDL= Radioisotope Direct Detection Laboratory, Simon Fraser University (inactive); GX=Geochron Laboratories; IGAN=Institute of Geography; LE=St. Petersburg; Mo=Institute of Geochemistry, Moscow (inactive).

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