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"The Good, the Bad, and the Ugly": evaluating the radiocarbon chronology of the middle and late Upper Paleolithic in the Enisei River valley, south-central Siberia

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ABSTRACT

The ^{14}C record for the Upper Paleolithic in Siberia has remained largely unevaluated and includes good, bad, and ugly dates. Too often researchers accept either all published dates or only those dates that tend to support proposed chronological hypotheses, regardless of sample quality and association. This article systematically evaluates all published ^{14}C dates (including several newly obtained AMS dates) from middle and late Upper Paleolithic sites in the Enisei River valley of south-central Siberia to establish a reliable chronology for the region and address the tempo of modern human dispersals in Siberia during late Pleistocene times. The revised chronology indicates humans were present before and after the Last Glacial Maximum, but absent during this climatic event. Results also suggest that human population in the region may have increased during the Oldest Dryas.

1. Introduction

During late marine isotope stage (MIS) 3 (26,000–21,000 ^{14}C [31,000–24,500 cal] BP), middle Upper Paleolithic (MUP) hunter-gatherers occupied the Enisei region of south-central Siberia. They procured a variety of faunal resources and supported their subsistence with flake and blade core technologies to make unifacial, bifacial, and burin tools. Following the Last Glacial Maximum (LGM) of MIS-2, after about 17,500 ^{14}C (21,000 cal) BP, the region was inhabited by late Upper Paleolithic (LUP) foragers equipped with microblade technologies. They, too, exploited a diversity of fauna; however, they primarily focused their attention on a narrower set of resources.

Recent debate has centered on whether people were capable of inhabiting Siberia during the intervening LGM (Dolukhanov et al., 2002; Goebel, 1999, 2002; Graf, 2005; Kuzmin, 2008; Kuzmin and Keates, 2005a,b; Vasil'ev et al., 2002). Opinions are linked to acceptance or rejection of ^{14}C assays dating from 20,000 to 18,000 ^{14}C (24,000–21,500 cal) BP. Based on a perceived lack of unequivocally dated, LGM-aged cultural occupations, Goebel (1999, 2002) argues MUP hunter-gatherers depopulated Siberia as a result of harsh climatic conditions; an interpretation first suggested by Russian geologist Tseitlin (1979) and one that continues to find support (Dolukhanov et al., 2002; Graf, 2005; Surovell et al., 2005). Conversely, Kuzmin (2008) (Kuzmin and Keates, 2005a,b) argues there are 18 sites in Siberia and the Russian Far East dating to the LGM, for example Tarachikha, Shlenka, Ui-1 (MUP), and Novoselovo-6 (LUP) in the Enisei River valley. In each of these cases there are problems, primarily contextual in origin. Pettitt et al. (2003) warned against blind acceptance of ^{14}C dates, arguing archaeologists need to critically evaluate ^{14}C determinations and reject those potentially unreliable or unsupportable. Most Siberian studies have largely ignored such warnings, instead treating ^{14}C dates as if they were never problematic, which has been repeatedly shown not to be the case (Goebel and Aksenov, 1995; Goebel et al., 1993, 2000, 2003).

Another problem is that typically most analyses of Siberian Upper Paleolithic chronology concentrate on dates from all of Siberia, glossing over important geologic and taphonomic contextual information regarding each date's reliability, as well as important regional environmental and climatic differences (e.g., including sites from Sakhalin Island and central Siberia in the same analysis) (Dolukhanov et al., 2002; Goebel, 1999; Kuzmin, 2008; Kuzmin and Keates, 2005a; Kuzmin and Orlova, 1998; Vasil'ev et al., 2002; but see Goebel, 2002, 2004). A regional perspective, weighing strengths and weaknesses of chronological data on a site-by-site basis, is needed to effectively evaluate the ^{14}C record. As Kuzmin and Keates (2005a: p. 773) so aptly state in their article

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title, "Dates are not just data," critical evaluation of specific chronological data is needed to establish reliable age estimates for chronology building (Pettitt et al., 2003). In this paper, therefore, I evaluate the MUP and LUP chronology for a single region of Siberia, the Enisei River valley (Fig. 1). First, I present new accelerator-mass-spectrometry (AMS) ^{14}C dates from five sites. Second, I use a modified version of Pettitt et al.'s (2003) criteria to objectively evaluate the current MUP and LUP ^{14}C data set for the region and reject obviously aberrant dates. Finally, because the criterion-based evaluation was not effective in this case, I provide a second evaluation that takes a more in-depth look at important site-specific information to help ensure site context and stratigraphic integrity of accepted date samples. The result is a relatively reliable chronology for the region, though one that will need continued refinement and rigorous testing.

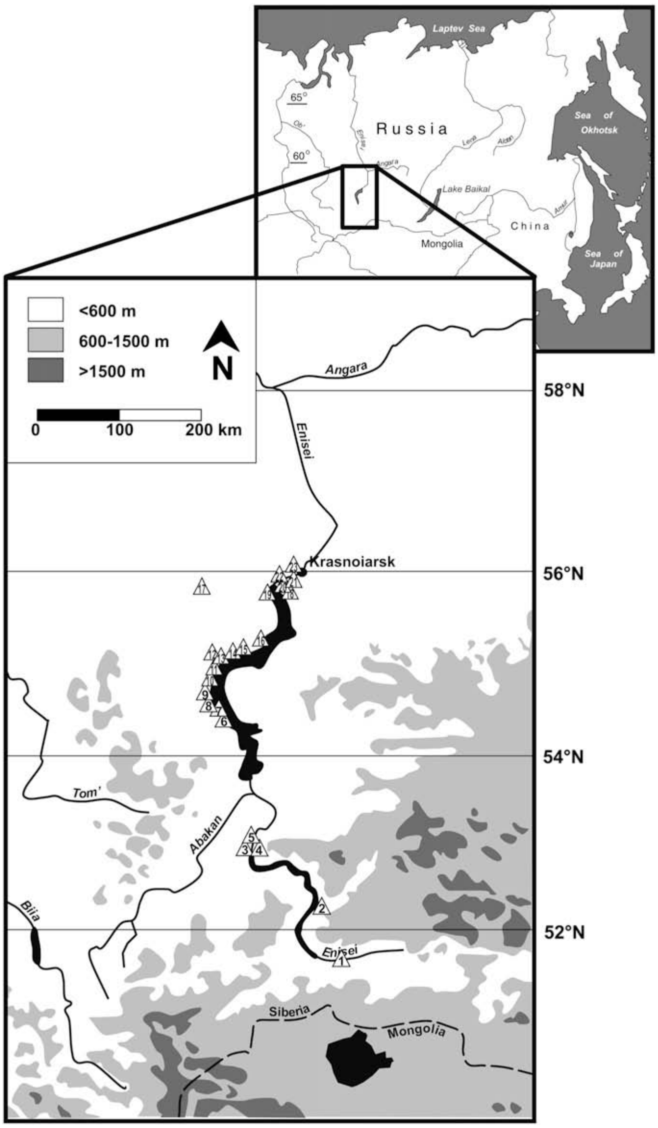

Fig. 1. Map of Enisei River sites mentioned in text and tables. 1: Kuilug Khem-1; 2: Nizhnii Idzhir-1; 3: Ui-1, Ui-2, Maininskaia East and West; 4: Golubaia-1; 5: Oznachennoe-1; 6: Pritubinsk; 7: Sabanikha; 8: Tashtyk-1, Tashtyk-2, Tashtyk-4; 9: Pervomoiskoe-1; 10: Kokorevo-1, Kokorevo-2, Kokorevo-3, Kokorevo-4a, Kokorevo-4b; 11: Novoselovo-6, Novoselovo-7, Novoselovo-13; 12: Tarachikha; 13: Divnyi-1; 14: Kashtanka-1; 15: Kurtak-3, Kurtak-4; 16: Shlenka; 17: Berezovyi Ruchei-1; 18: Konzhul; 19: Biriusa-1; 20: Listvenka; 21: Bolshaia Slizneva; 22: Eleneva Cave; 23: Afontova Gora-2.

2. Absolute dating of Upper Paleolithic sites from the Enisei

2.1. Existing record

The ^{14}C method has been employed to date most Upper Paleolithic sites in Siberia, primarily because the time period of concern falls well within the accepted age range of the method ($\leq$45,000 ^{14}C BP) (Bronk Ramsey et al., 2004a; Mellars, 2006). The existing chronology, however, has been built almost exclusively on conventional ^{14}C dates because there are no AMS ^{14}C laboratories in Russia. In the Enisei region, only 11 of 161 ^{14}C dates previously reported from MUP and LUP contexts were obtained using AMS methods (Table 1). The AMS method permits dating of significantly smaller samples than the conventional method, thereby allowing for selection of more suitable samples and obviating the need to pool samples for bulk dates (Mellars, 2006). It also facilitates more effective sample pretreatment, especially small samples of bone protein (Bronk Ramsey et al., 2004b; Mellars, 2006). Bone is inherently porous with high potential for contamination by recent carbon. In conventional analysis whole bone samples (including apatite and collagen) were traditionally used. Contamination can occur in bone apatite during recrystallization and surface exchange reactions (Haynes, 1968). As a result, recent efforts have concentrated on separating various small fractions (i.e., humates, apatite, collagen, specific amino acids) of a sample and dating them with AMS methods (Long et al., 1989; Stafford et al., 1982, 1987, 1988, 1991; Taylor, 1992). For the Enisei data set 74 samples were bone; some were pre-treated collagen while many others were combined collagen and apatite.

2.2. New AMS dates

Preserved samples from several collections of previously excavated MUP and LUP sites were re-dated using the AMS method. Samples came from curated collections housed in the Institute for Material Culture History and Hermitage State Museum, St. Petersburg, Russia (Table 2). Pretreatment and AMS analyses of wood charcoal and bone samples were conducted at the NSF-Arizona AMS Facility, University of Arizona, Tucson, and followed standard methods described by Jull et al. (1983) and Long et al. (1989). Of the 17 samples, only 14 dates were obtained because three bone samples contained insufficient collagen for dating. Results are discussed below on a site-by-site basis.

2.2.1. Sabanikha

Three dispersed charcoal samples from the Sabanikha cultural layer yielded dates of 26,520 ± 250 (AA-68665), 25,960 ± 240 (AA-68666), and 25,660 ± 250 (AA-68667) BP (Table 2). D. Rhode (Desert Research Institute [DRI], Reno, U.S.A.) identified the samples as conifer (spruce, larch, or pine). New dates overlap with two previously obtained, conventional dates at 2-σ. Therefore, five of the seven age estimates now available for Sabanikha suggest an age of 27,000–24,500 ^{14}C BP (Tables 1 and 2).

2.2.2. Kurtak-4

Five hearth charcoal samples from Kurtak-4 (cultural layer 1), produced dates of 27,770 ± 310 (AA-68668), 25,160 ± 280 (AA-68669), 21,270 ± 160 (AA-72147), 20,690 ± 240 (AA-72146), and 17,740 ± 120 (AA-68670) BP (Table 2). These results are perplexing since only two assays overlap (2-σ) despite that all were collected from the same hearth feature and derived from the same charcoal type. Together, one new (AA-68669) and five previously reported dates (Table 1) that overlap (2-σ) suggest an age for cultural layer 1 of 26,000–24,000 ^{14}C BP. Radiocarbon dating of Kurtak-4 provides a good example of potential problems with dating charcoal from

Table 1
Previously reported ^{14}C dates for MUP and LUP sites in the Enisei River valley.

Site[a]	Lab number[b]	Material	Age estimate	Age estimate range (2-σ)	Reference[c]	Criteria evaluation score	Final evaluation
Kuilug Khem-1							
CL 4	LE-6899	Bone	23,600 ± 400	24,400–22,800	1	8-Ugly	Accepted
CL 3	LE-6901	Bone	15,500 ± 180	15,860–15,140	1	8-Ugly	Accepted
Nizhnii Idzhir-1							
CL	LE-1984	Hearth charcoal	17,200 ± 70	17,340–17,060	2	12-Ugly	Accepted
Ui-1							
CL 2	LE-4189	Dispersed charcoal	22,830 ± 530	23,890–21,770	3,4	8-Ugly	Accepted
CL 2	LE-4257	Bone	19,280 ± 200	19,680–18,880	3	10-Ugly	Accepted
CL 2	AA-38054[d]	Bone	17,690 ± 210	18,110–17,270	5	9-Ugly	Rejected
CL 2	LE-3359	Bone	17,520 ± 130	17,780–17,260	3	10-Ugly	Rejected
CL 2	LE-3358	Bone	16,760 ± 120	17,000–16,520	3	9-Ugly	Rejected
Maininskaia West							
CL B	LE-2383	Dispersed charcoal	15,200 ± 150	15,500–14,900	3	10-Ugly	Accepted
CL A3	AA-38055[d]	Bone	19,300 ± 350	20,000–18,550	5	11-Ugly	Rejected
CL A1-A3	LE-3019	Dispersed charcoal	11,700 ± 100	11,900–11,500	3	12-Ugly	Accepted
CL A1	LE-4255	Bone	12,110 ± 220	12,550–11,670	3	10-Ugly	Accepted
Maininskaia East							
CL 5	LE-2135	Bone	16,540 ± 170	16,880–16,200	3	11-Ugly	Accepted
CL 5	LE-2135	Bone	16,176 ± 180	16,536–15,816	3	11-Ugly	Accepted
CL 4	LE-4251	Bone	13,690 ± 390	14,470–12,910	3	12-Ugly	Accepted
CL 4	LE-2133	Bone	12,980 ± 130	13,240–12,720	3	13-Ugly	Accepted
CL 4	LE-2133	Bone	12,900 ± 100	13,100–12,700	3	13-Ugly	Accepted
CL 3	LE-2149	Bone	14,070 ± 150	14,370–13,770	3	11-Ugly	Rejected
CL 3	LE-2149	Bone	13,900 ± 150	14,200–13,600	3	11-Ugly	Rejected
CL 3	LE-2149	Bone	12,330 ± 150	12,630–12,030	3	11-Ugly	Accepted
CL 3	LE-4252	Bone	12,120 ± 650	13,420–10,820	3	8-Ugly	Accepted
CL 2-2	LE-2378	Dispersed charcoal	10,800 ± 200	11,200–10,400	3	7-Bad	Rejected
CL 2-1	LE-2300	Bone	12,280 ± 150	12,580–11,980	3	11-Ugly	Accepted
CL 2-1	LE-2300	Bone	12,120 ± 120	12,360–11,880	3	11-Ugly	Accepted
Ui-2							
CL 7	AA-38050[d]	Bone	14,150 ± 140	14,430–13,870	5	14-Ugly	Accepted
CL 6	LE-3717	Dispersed charcoal	14,310 ± 3,600	21,510–7,110	6	8-Ugly	Rejected
CL 6	AA-60038[d]	Bone	13,900 ± 150	14,200–13,600	7	16-Ugly	Accepted
CL 5	AA-60037[d]	Bone	12,440 ± 130	12,700–12,180	7	12-Ugly	Rejected
CL 4	AA-38049[d]	Bone	13,480 ± 140	13,760–13,200	5	14-Ugly	Accepted
CL 4	LE-3609	Dispersed charcoal	11,970 ± 230	12,430–11,510	6	9-Ugly	Rejected
CL 4	LE-3713	Dispersed charcoal	10,760 ± 420	11,600–9920	6	8-Ugly	Rejected
CL 3[a]	AA-38048[d]	Bone	12,970 ± 120	13,210–12,730	5	16-Ugly	Accepted
CL 3	AA-38047[d]	Bone	12,880 ± 60	13,000–12,760	5	16-Ugly	Accepted
CL 2	AA-60036[d]	Bone	13,260 ± 270	13,800–12,720	7	11-Ugly	Accepted
Golubaia-1							
CL 3	LE-1101 g[e]	Bone	13,650 ± 180	14,010–13,290	2	9-Ugly	Rejected
CL 3	LE-1101[e]	Hearth charcoal	13,050 ± 90	13,230–12,870	2	16-Ugly	Accepted
CL 3	LE-1101v[e]	Bone	12,980 ± 140	13,260–12,700	2	13-Ugly	Accepted
CL 3	LE-1101b[e]	Bone	12,900 ± 150	13,200–12,600	2	13-Ugly	Accepted
Oznachennoe-1							
CL	LE-1404[f]	Bone	15,020 ± 150	15,320–14,720	2,9	9-Ugly	Accepted
CL	LE-1404[f]	Bone	14,100 ± 150	14,400–13,800	8,9	9-Ugly	Accepted
Pritubinsk							
CL 3	SOAN-2854	Dispersed charcoal	15,600 ± 495	16,590–14,610	9	7-Bad	Rejected
Sabanikha							
CL	LE-3747	Bone	25,950 ± 500	26,950–24,950	10	14-Ugly	Accepted
CL	LE-4796	Dispersed charcoal	25,440 ± 450	26,340–24,540	10	13-Ugly	Accepted
CL	LE-3611	Dispersed charcoal	22,930 ± 350	23,630–22,230	10	10-Ugly	Accepted
CL	LE-4701	Dispersed charcoal	22,900 ± 480	23,860–21,940	10	9-Ugly	Accepted
Tashtyk-1							
CL 1	LE-4980	Bone	12,880 ± 130	13,140–12,620	6	9-Ugly	Accepted
CL 1	LE-771	Dispersed charcoal	12,180 ± 120	12,420–11,940	11	10-Ugly	Accepted
Tashtyk-2							
CL	LE-4801	Bone	13,550 ± 320	14,190–12,910	6	8-Ugly	Accepted
Tashtyk-4							
CL 2	GIN-262	Dispersed charcoal	14,700 ± 150	15,000–14,400	12	9-Ugly	Accepted
Pervomaiskoe-1							
Surface	LE-4893	Bone	12,870 ± 140	13,150–12,590	10	5-Bad	Rejected
Kokorevo-1							
CL 3	IGAN-104	Dispersed charcoal	15,900 ± 250	16,400–15,400	8,9	7-Bad	Rejected
CL 3	LE-628	Hearth charcoal	14,450 ± 150	14,750–14,150	11	12-Ugly	Accepted

Table 1 (*continued*)

Site[a]	Lab number[b]	Material	Age estimate	Age estimate range (2-σ)	Reference[c]	Criteria evaluation score	Final evaluation
CL 3	GIN-91	Hearth charcoal	13,300 ± 50	13,400–13,200	11	14-Ugly	Accepted
CL 3	IGAN-102[g]	Bone	13,000 ± 50	13,100–12,900	9,13	9-Ugly	Accepted
CL 2	IGAN-105	Dispersed charcoal	15,200 ± 200	15,600–14,800	8	7-Bad	Rejected
CL 2	IGAN-103	Bone	13,100 ± 500	14,100–12,100	13	9-Ugly	Accepted
CL 2	LE-526	Hearth charcoal	12,940 ± 270	13,480–12,400	11	13-Ugly	Accepted
Kokorevo-2							
CL	GIN-90	Hearth charcoal	13,330 ± 100	13,530–13,130	14	12-Ugly	Accepted
CL	LE-4812	Bone	12,090 ± 100	12,290–11,890	10	9-Ugly	Accepted
Kokorevo-3							
CL	LE-629	Dispersed charcoal	12,690 ± 140	12,970–12,410	11	9-Ugly	Accepted
Kokorevo-4[a]							
CL 5-3	LE-469	Dispersed charcoal	14,320 ± 330	14,980–13,660	14	8-Ugly	Accepted
Kokorevo-4[b]							
CL 2	LE-540	Hearth charcoal	15,460 ± 320[a]	16,100–14,820	14	11-Ugly	Accepted
Novoselovo-6							
CL	LE-4807	Bone (reindeer)	18,090 ± 940	19,970–16,210	10	6-Bad	Rejected
CL	LE-5045	Bone	13,570 ± 140	13,850–13,290	10	9-Ugly	Rejected
CL	GIN-403	Hearth charcoal	11,600 ± 500[b]	12,600–10,100	14	10-Ugly	Accepted
Novoselovo-7							
CL	LE-4802	Bone (reindeer)	15,950 ± 120	16,190–15,710	15	9-Ugly	Rejected
CL	GIN-402	Dispersed charcoal	15,000 ± 300	15,600–14,300	14	10-Ugly	Accepted
CL	LE-4803	Bone (reindeer)	14,220 ± 170	14,560–13,880	15	15-Ugly	Accepted
Novoselovo-13							
CL 3	LE-3739	Hearth charcoal	22,000 ± 700	23,400–20,600	8	9-Ugly	Accepted
CL 1	LE-4896	Bone (reindeer)	15,030 ± 620	16,270–13,790	10	9-Ugly	Accepted
CL 1	LE-4805	Bone (reindeer)	13,630 ± 200	14,030–13,230	10	11-Ugly	Accepted
Tarachikha							
Surface	LE-3821	Bone (reindeer)	19,850 ± 180	20,210–19,490	10	11-Ugly	Rejected
Surface	LE-3834	Bone (mammoth)	18,930 ± 320	19,570–18,290	10	10-Ugly	Rejected
Divnyi-1							
CL	LE-4806	Bone	13,220 ± 150	13,520–12,920	10	9-Ugly	Accepted
Kurtak-3							
EB 1, CL	GIN-2102	Hearth charcoal	16,900 ± 700	18,300–15,500	13	7-Bad	Rejected
EB 1, CL	LE-1456	Hearth charcoal	14,390 ± 100	14,590–14,190	13	16-Ugly	Accepted
EB 2, CL	GIN-2101	Hearth charcoal	14,600 ± 200	15,000–14,200	13	15-Ugly	Accepted
EB 2, CL	LE-1457	Hearth charcoal	14,300 ± 100	14,500–14,100	13	16-Ugly	Accepted
Kurtak-4							
Str 11/CL 1	LE-3357	Hearth charcoal	24,890 ± 670	26,230–23,550	8	15-Ugly	Accepted
Str 11/CL 1	GIN-5350	Hearth charcoal	24,800 ± 400	25,600–24,000	8	16-Ugly	Accepted
Str 11/CL 1	LE-3351	Hearth charcoal	24,170 ± 230	24,630–23,710	16	17-Ugly	Accepted
Str 11/CL 1	LE-4156	Bone (near hearth)	24,000 ± 5,900	35,800–12,200	16	16-Ugly	Rejected
Str 11/CL 1	LE-4155	Hearth charcoal	23,800 ± 900	25,600–22,000	16	15-Ugly	Rejected
Str 11/CL 1	LE-2833[a]	Hearth charcoal	23,470 ± 200	23,870–23,070	16	16-Ugly	Accepted
Kashtanka-1							
Str 9/CL	SOAN-2853	Hearth charcoal	24,805 ± 425	25,655–23,955	16	12-Ugly	Rejected
Str 9/CL	IGAN-1049	Dispersed charcoal	21,800 ± 200	22,200–21,400	16	12-Ugly	Accepted
Str 9/CL	GIN-6968	Hearth charcoal	20,800 ± 600	22,000–19,600	16	13-Ugly	Accepted
Shlenka							
Surface	GIN-2863	Tusk (mammoth)	20,100 ± 100	20,300–19,900	17	15-Ugly	Rejected
Surface	GIN-2861	Bone (mammoth)	19,700 ± 200	20,100–19,300	17	19-Ugly	Rejected
CL	GIN-2862	Bone (horse/bison)	18,600 ± 2,000	22,600–14,600	17	6-Bad	Rejected
CL	GIN-2862[a]	Bone (horse/bison)	17,660 ± 700	19,060–16,260	17	6-Bad	Rejected
Berezovyi Ruchei-I							
CL	LE-4895	Bone (reindeer)	15,210 ± 560	16,330–14,090	10	8-Ugly	Accepted
Konzhul							
LUP CL	SOAN-4954	Unreported	12,160 ± 175	12,510–11,810	7	10-Ugly	Accepted
LUP CL	SOAN-4953	Unreported	11,980 ± 155	12,290–11,670	7	10-Ugly	Accepted
Biriusa-1							
CL 4	LE-4912	Bone	14,700 ± 270	15,240–14,160	18	12-Ugly	Accepted
CL 4	LE-4910	Bone	14,680 ± 180	15,040–14,320	18	13-Ugly	Accepted
CL 4	GIN-8077	Bone	14,200 ± 70	14,340–14,060	10	13-Ugly	Accepted
CL 4	GIN-8075	Bone	13,840 ± 90	14,020–13,660	10	9-Ugly	Accepted
CL 3[a]	LE-3777	Bone	14,480 ± 400	15,240–13,680	18	7-Bad	Rejected
Listvenka							
CL 20	SOAN-4795	Bone (mammoth)	20,610 ± 380	21,370–19,850	19	6-Bad	Rejected
CL 20	GIN-6093	Bone (mammoth.)	16,450 ± 600	17,650–15,250	19	6-Bad	Rejected

(*continued on next page*)

Table 1 (*continued*)

Site[a]	Lab number[b]	Material	Age estimate	Age estimate range (2-σ)	Reference[c]	Criteria evaluation score	Final evaluation
CL 19	SOAN-5084	Bone (mammoth)	17,200 ± 230	17,660–16,740	19	11-Ugly	Accepted
CL 19	SOAN-3734	Dispersed charcoal	16,640 ± 350	17,340–15,940	19	10-Ugly	Accepted
CL 15	SOAN-3314	Hearth charcoal	17,080 ± 485	18,050–16,110	19	10-Ugly	Accepted
CL 12	Beta-58391[d]	Hearth charcoal	19,000 ± 660	20,320–17,680	20	11-Ugly	Rejected
CL 12	SOAN-3833	Bone (bison)	13,910 ± 400	14,710–13,110	19	15-Ugly	Accepted
CL 12	SOAN-3733	Dispersed charcoal	13,470 ± 285	14,040–12,900	19	14-Ugly	Accepted
CL 12	SOAN-4868	Bone (bison)	13,260 ± 160	13,580–12,940	19	15-Ugly	Accepted
CL 12	GIN-6965	Hearth charcoal	13,100 ± 410	13,920–12,280	21	15-Ugly	Accepted
CL 10	SOAN-5083	Bone (bison)	13,200 ± 110	13,420–12,980	19	10-Ugly	Accepted
CL 9	SOAN-3834	Bone (bison)	14,580 ± 320	15,220–13,940	19	9-Ugly	Rejected
CL 9	GIN-6967	Hearth charcoal	14,170 ± 80	14,330–14,010	21	12-Ugly	Rejected
CL 8	IGAN-1078	Hearth charcoal	12,750 ± 140	13,030–12,470	16	12-Ugly	Accepted
CL 7	GIN-6092	Dispersed charcoal	14,750 ± 250	15,250–14,250	16	8-Ugly	Rejected
CL 6	SOAN-3463	Hearth charcoal	13,850 ± 485	14,820–12,880	19	10-Ugly	Rejected
CL 6	IGAN-1079	Hearth charcoal	13,590 ± 350	14,290–12,890	16	11-Ugly	Rejected
Bolshaia Slizneva							
CL 8	SOAN-3315	Dispersed charcoal	13,540 ± 500	14,540–12,540	22	8-Ugly	Accepted
CL 7	SOAN-3009	Bone	12,930 ± 60	13,050–12,810	22	9-Ugly	Accepted
Eleneva Cave							
EB 1	SOAN-3333	Bone	13,665 ± 90	13,845–13,485	22	6-Bad	Rejected
EB 2	SOAN-3309	Dispersed charcoal	12,085 ± 105	12,295–11,875	22	8-Ugly	Accepted
EB 2	SOAN-3307	Dispersed charcoal	12,050 ± 325	12,700–11,400	22	7-Bad	Rejected
EB 2	SOAN-3308	Dispersed charcoal	12,040 ± 160	12,360–11,720	22	8-Ugly	Accepted
EB 2	SOAN-3310	Bone	11,430 ± 115	11,660–11,200	7	6-Bad	Rejected
CL 21	SOAN-3256	Unreported	10,395 ± 85	10,565–10,225	7	6-Bad	Rejected
CL 21	SOAN-3255	Bone	10,380 ± 85	10,550–10,210	7	7-Bad	Rejected
CL 20	SOAN-3254	Bone	10,460 ± 95	10,650–10,270	7	6-Bad	Rejected
CL 19	SOAN-3253	Bone	11,250 ± 335	11,920–10,580	7	5-Bad	Rejected
CL 18	SOAN-3252	Bone	12,040 ± 150	12,340–11,740	7	6-Bad	Rejected
CL 17-16	SOAN-2948	Dispersed charcoal	10,845 ± 310	11,465–10,225	7	5-Bad	Rejected
Afontova Gora-2, Old excavation							
CL C_3	GIN-117	Dispersed charcoal	20,900 ± 300	21,500–20,300	12	4-Bad	Rejected
Afontova Gora-2, Drozdov excavation							
Str 12	GrA-5554[d]	Dispersed charcoal	14,180 ± 60	14,300–14,060	23	6-Bad	Rejected
Str 12/CL6	GrA-5553 [d]	Unreported	14,140 ± 60	14,260–14,020	24	6-Bad	Rejected
Str 12/CL6	SOAN-5125	Unreported	12,560 ± 70	12,700–12,420	24	6-Bad	Rejected
Str 12	GrA-5555[d]	Dispersed charcoal	12,400 ± 60	12,520–12,280	23	6-Bad	Rejected
Str 11	SOAN-5124	Unreported	12,050 ± 75	12,200–11,900	24	4-Bad	Rejected
Str 11-10/CL 5	SOAN-3251	Dispersed charcoal	15,130 ± 795	16,720–12,745	23	6-Bad	Rejected
Str 9/CL 4	SOAN-3075	Dispersed charcoal	14,070 ± 110	14,290–13,850	23	11-Ugly	Accepted
Str 9/CL 4	GIN-7541	Dispersed charcoal	13,930 ± 80	14,090–13,770	23	11-Ugly	Accepted
Str 9/CL 4	GIN-7540	Dispersed charcoal	13,650 ± 70	13,790–13,510	23	10-Ugly	Accepted
Str 6	GrN-22275	Dispersed charcoal	13,930 ± 260	14,190–13,410	23	5-Bad	Rejected
Str 5/CL 3	SOAN-3077	Dispersed charcoal	14,300 ± 95	14,205–14,015	23	9-Ugly	Accepted
Str 5/CL 3	GrN-22274	Dispersed charcoal	13,990 ± 110	14,210–13,770	23	9-Ugly	Accepted
Str 5/CL 3	SOAN-5123	Unreported	13,600 ± 80	13,760–13,440	24	9-Ugly	Accepted
Str 5/CL 3	GIN-7539	Dispersed charcoal	13,350 ± 60	13,470–13,230	23	9-Ugly	Accepted
Str 5/CL 2	GrA-5556[d]	Dispersed charcoal	14,200 ± 60	14,320–14,080	23	9-Ugly	Accepted
Str 5/CL 2	GIN-7542	Dispersed charcoal	13,330 ± 140	13,610–13,050	23	9-Ugly	Accepted
Afontova Gora-5							
Unreported	SOAN-3781	Unreported	27,890 ± 690	29,270–26,510	24	1-Bad	Rejected

[a] CL = cultural layer; EB = excavation block; Str = stratum.
[b] ^{14}C laboratory designations are LE: Institute for Material Culture History, RAN, St. Petersburg, Russia; GIN: Institute of Geology, RAN, Moscow, Russia; IGAN: Institute of Geography, RAN, Moscow, Russia; SOAN: Institute of Geology and Mineralogy, RAN, Novosibirsk, Russia; GrN (conventional ^{14}C) and GrA (AMS): Groningen University, Netherlands; Beta: Beta Analytic, Inc., Miami, USA; and AA: NSF-University of Arizona, Tucson, USA.
[c] References: (1) Semenov et al. (2005); (2) Astakhov (1986); (3) Vasil'ev (1996); (4) Vasil'ev, personal communication, October 2006; (5) Vasil'ev et al. (2005a); (6) Lisitsyn and Svezhentsev (1997); (7) Vasil'ev et al. (2005b); (8) Svezhentsev et al. (1992); (9) Vasil'ev et al. (2002); (10) Lisitsyn (2000); (11) Abramova (1979a); (12) Tseitlin (1979); (13) Abramova et al. (1991); (14) Abramova (1979b); (15) Lisitsyn (1996); (16) Drozdov et al. (1990); (17) Iamskikh and Iamskikh (1992); (18) Kuzmina and Sinitsyna (1995); (19) Akimova et al. (2005); (20) Goebel, personal communication, January 2007; (21) Akimova et al. (1992); (22) Orlova (1995); (23) Drozdov and Artem'ev (1997); (24) Drozdov and Artem'ev (2007).
[d] AMS ^{14}C date.
[e] It is not clear why all four dates have the same lab number, LE-1101; however, LE-1101 g, LE-1101v, and LE-1101b were obtained on three pieces of the same bone.
[f] These samples were obtained on the same bone and thus have the same lab number.
[g] The lab number for this sample was originally published by Abramova et al. (1991) as IGAN-104; however, Vasil'ev et al. (2002) reported it as IGAN-102. Vasil'ev (personal communication, September 2008) recently explained to me that in preparation of the 2002 publication he personally verified lab numbers and dates from these sites by looking through original lab reports. Also, Abramova et al. (1991) reported this date to be 13,000 ± 500; however, Vasil'ev et al. (2002) reported it as 13,000 ± 50.

Paleolithic sites in Siberia, and shows it is necessary to individually consider the specific context and history of dates from each site.

2.2.3. Novoselovo-7

Five bone samples from the Novoselovo-7 cultural layer were submitted, but only three had sufficient collagen for analysis, producing dates of 13,800 ± 140 (AA-68674), 13,480 ± 140 (AA-68672), and 11,700 ± 110 (AA-72561) BP. The first two age estimates overlap (2-σ). The third, however, is at least 2000 ^{14}C years younger than the other two. Of the three conventional ages previously reported for this site (Table 1), only two (GIN-402, LE-4803) overlap (2-σ) with each other and

Table 2
New AMS ^{14}C dates for MUP and LUP sites in the Enisei River valley.

Site name[a]	Lab number	Material	$\Delta^{13}C$	Age estimate[b]	Age Range (2-σ)	Criteria Evaluation Score	Final Evaluation
Sabanikha, CL							
	AA-68665	Dispersed charcoal[c]	−22.5	26,520 ± 250	27,020–26,020	18-Ugly	Accepted
	AA-68666	Dispersed charcoal[c]	−24.4	25,960 ± 240	26,440–25,480	18-Ugly	Accepted
	AA-68667	Dispersed charcoal[c]	−24.0	25,660 ± 250	26,160–25,160	18-Ugly	Accepted
Kurtak-4, CL 1							
K28-30/L28-29	AA-68668	Hearth charcoal[d]	−23.7	27,770 ± 310	28,390–27,150	16-Ugly	Rejected
K28-30/L28-29	AA-68669	Hearth charcoal[d]	−23.6	25,160 ± 280	25,720–24,600	24-Good	Accepted
K28-30/L28-29	AA-72147	Hearth charcoal[d]	−23.5	21,270 ± 160	21,590–20,950	19-Ugly	Rejected
K28-30/L28-29	AA-72146	Hearth charcoal[d]	−23.6	20,690 ± 240	21,170–20,210	18-Ugly	Rejected
K28-30/L28-29	AA-68670	Hearth charcoal[c]	−24.8	17,740 ± 120	17,980–17,500	15-Ugly	Rejected
Novoselovo-7, CL							
B6	AA-68673	Bone Collagen insufficient	–	Undatable			
A5	AA-68675	Bone Collagen insufficient	–	Undatable			
A5	AA-68674	Bone Collagen	−19.3	13,800 ± 140	14,080–13,520	18-Ugly	Accepted
A4	AA-68672	Bone Collagen	−18.3	13,480 ± 140	13,760–13,200	18-Ugly	Accepted
A5	AA-72561	Bone Collagen	−19.5	11,700 ± 110	11,920–11,480	12-Ugly	Rejected
Kokorevo-1, CL 3							
Shch49	AA-68671	Bone Collagen insufficient	–	Undatable			
Afontova Gora, Old Excavation, CL C_3							
D2	AA-68663	Dispersed charcoal[e,g]	−25.4	13,970 ± 80	14,130–13,810	15-Ugly	Accepted
D2	AA-68664	Dispersed charcoal[e,g]	−24.6	13,870 ± 80	14,030–13,710	15-Ugly	Accepted
D1	AA-68662	Dispersed charcoal[f,g]	−25.0	12,280 ± 80	12,440–12.120	11-Ugly	Rejected

[a] CL is cultural layer. K28–30, L28–29, B6, A5, A4, Shch49, D2, D1 are excavation squares.
[b] Age estimate in radiocarbon years before present; presented with 1-σ.
[c] Identified as Conifer (*Picea* or *Larix* sp.).
[d] Identified as Conifer (*Picea* or *Pinus* sp.).
[e] Identified as Angiosperm (*Salix* or *Calluna* sp.).
[f] Identified as Angiosperm (*Salix* or *Populus* sp.).
[g] Sosnovskii (1935) reported this charcoal from a living floor/dwelling feature; however, Astakhov (1999) recently argued that no such feature was present.

only one (LE-4803) overlaps with the two more ancient AMS dates.

2.2.4. Kokorevo-1

One piece of bone from the Kokorevo-1 assemblage was analyzed but produced insufficient collagen and remains undated.

2.2.5. Afontova Gora-2

Three dispersed wood charcoal samples from Afontova Gora-2 (cultural layer C_3) yielded age estimates of 13,970 ± 80 (AA-68663), 13,870 ± 80 (AA-68664), and 12,280 ± 80 (AA-68662) BP. D. Rhode identified the samples as angiosperms (Table 2). The first two dates (AA-68663, AA-68664) are in good agreement with each other and were obtained on samples from the same 1-m^2 excavation unit, while the third date (AA-68662) was excavated from an adjacent square and is roughly 1000 ^{14}C years younger.

3. Radiocarbon evaluation

Radiocarbon dating is not foolproof. Confidence in ^{14}C determinations changes regularly and interpretation of dates varies from person-to-person (Pettitt et al., 2003; Spriggs, 1989). In theory, evaluation of age determinations should consider both the methodologies employed by labs and the archaeological and geological situations from which samples originated. The latter can be a difficult task for the archaeologist evaluating data he or she did not collect, and often it is impossible to confidently evaluate reported associations between dated samples and archaeological events. Most often the best materials to date are single pieces of identified wood charcoal from hearth features or other organic materials clearly used by humans such as food or raw material resources (e.g., cut-marked bones, textiles); however, even these may not reflect the actual age of archaeological events because in regions where preservation is excellent (e.g., frozen northern sediments) dated, organic materials could have been scavenged by humans. Another important issue is potential movement of cultural materials via post-depositional processes caused by human actions or natural processes, an issue of great concern with multilayered sites. Simply put, interpretation of ^{14}C data requires rigorous evaluation of each date.

3.1. Objectively evaluating ^{14}C dates

Recently Pettitt et al. (2003) argued that to build reliable chronological models archaeologists need to quantifiably accept and reject ^{14}C dates. Pettitt and colleagues developed nine criteria with five ranks to systematize the evaluation process. These criteria are divided into two sets: (1) methodological criteria (1–5) related to selection and analysis of ^{14}C samples and (2) interpretative criteria (6–9) related to defining archaeological contexts.

Criteria proposed by Pettitt et al. (2003) permit systematic assessment of ^{14}C dates and are extremely useful when all information required is known (i.e., the researcher evaluating the dates also excavated the sites, selected the dating samples, and selected the ^{14}C lab). In many situations, however, not all ^{14}C determinations can be evaluated according to all criteria, especially when evaluating previously published dates. For this study much of the information needed for evaluation was unavailable, or the pre-defined ranks did not predict all situations encountered. Typically, the criteria hardest to evaluate were methodological in nature. Most previously reported dates were published without chemical fraction information, and often general identification information was unavailable (e.g., hearth or dispersed wood charcoal). Therefore, Pettitt et al.'s (2003) criteria used in this study were those related to interpreting ^{14}C samples and dates. From Pettitt et al.'s (2003) list, I developed a set of seven criteria to evaluate the Siberian data (Table 3), including minor revision of four Pettitt et al. (2003) criteria (criteria 2–5) and three new criteria (criteria 1, 6, and 7). Criterion 1

Table 3
Seven ^{14}C sample criteria and ranks used in the current study.

1. Sample type choice:
   0. Dispersed charcoal or dispersed bone with dated fraction unknown or not reported.
   1. Dispersed charcoal found associated with cultural feature (e.g., activity area, "living floor" debris) or dispersed bone with collagen separated and dated.
   2. Hearth charcoal not identified or dispersed bone found associated with cultural feature (e.g., "living floor" debris) with collagen separated and dated.
   3. Identified hearth charcoal with "old wood" not ruled out or dispersed bone with specific amino acids identified.
   4. Identified hearth charcoal with "old wood" ruled out or cut-marked bone with specific amino acids identified.
2. Sample measurement and lab reporting[a]:
   0. Conventional date before 1970 and/or bulk sample (or bulk sample can not be ruled out).
   1. Sample pre-treated and/or analyzed at non-IRI lab.
   2. Determination published without pretreatment and analysis methods or results do not fit lab's assessment criteria.
   3. Determination published with assessment data but some criteria were outside acceptable limits.
   4. Determination published with full pretreatment, analysis, and isotope data and all satisfy acceptable criteria.
3. Positive association of sample and archaeology[a]:
   0. Association unlikely (i.e., paleontological setting).
   1. Association possible due to presence of archaeology; however, materials diffusely distributed.
   2. Association likely due to numbers and spatial patterning of cultural remains.
   3. Association highly likely due to demonstrated functional relationship.
   4. Full certainty of association due to direct assay on anthropogenic item.
4. Relevance of dating sample to a specific diagnostic archaeological phenomenon[a]:
   0. Sample material unknown.
   1. No traces of human manufacture or modification on sample or if charcoal, "old wood" cannot be ruled out.
   2. Sample highly associated with diagnostic archaeology but, it is not diagnostic.
   3. Association highly likely because sample was found in cultural feature such as hearth.
   4. Sample diagnostic of cultural period or is a highly associated item showing clear signs of human modification.
5. Quantity and character of age estimates[a]:
   1. Determination is 1 of only 2 for given cultural layer and overlaps at 2-σ range.
   0. Only determination for given cultural layer or 1 of several that fall outside of a 2-σ range.
   2. Determination is 1 of 3 in a given cultural layer that overlap at 2-σ range.
   3. Determination is 1 of 4 in a given cultural layer that overlap at 2-σ range.
   4. Determination is 1 of 5 in a given cultural layer that overlap at 2-σ range.
6. Standard deviation[b]:
   0. $> \pm 1000$.
   1. ± 600–1000.
   2. ± 400–599.
   3. ± 200–399.
   4. $< \pm 200$.
7. Stratigraphic context and age of sample:
   0. No obvious correlation between age and stratigraphic context or stratigraphic context unknown.
   1. Age determination does not fit stratigraphic context but overlaps at 2-σ with 1 or more other determinations in stratum or cultural layer.
   2. Age determination is only date and fits stratigraphic context or does not overlap with other determinations at 2-σ.
   3. Age determination fits stratigraphic context and overlaps at 2-σ with at least 1 other determination.
   4. Age determination fits stratigraphic context and overlaps at 2-σ with at least 2 other determinations.

[a] From Pettitt et al. (2003).
[b] Standard deviations are large because most ages from Upper Paleolithic sites in Siberia are conventional dates run in labs that did not attempt finer precision used by other labs (<150 years).

deals specifically with the choice of sample type, explicitly ranking suitability of types dated (e.g., identified hearth charcoal over dispersed charcoal), and criteria 6 and 7 deal with standard-deviation size and stratigraphic context, respectively.

Seven evaluation criteria with ranks of 0–4 were used (with 4 being the highest), so total scores ranged from 0 to 28. Results of ranked data were assembled into three groups, somewhat analogously to the main characters in the 1966 movie, "The Good, the Bad, and the Ugly" (Produzioni Europee Associates, Alberto Grimaldi Productions, SA [PWH]) (Fig. 2). Following Pettitt et al.'s (2003) scoring system, good dates have scores ranging from 21 to 28. These are solid, reliable age determinations. An example of a good date is a piece of identified wood charcoal from a hearth feature, published with lab assessment data, and expressing a clear functional relationship between the sample and archaeological materials. It would overlap (2-σ) with other dates, have a small standard deviation, and fit within a logical chronostratigraphic context. Bad dates have scores ranging from 0 to 7. They are untrustworthy, unreliable determinations. Often, bad dates come from unidentified samples, are not found in association with cultural materials, do not overlap at 2-σ with other dates, have large standard deviations, and/or do not fit into logical stratigraphic sequences. Ugly dates have scores ranging from 8 to 20. They may be somewhat reliable, but should be treated with caution. Ugly dates are typically from problematic stratigraphic contexts, published without assessment data, found in questionable association with cultural materials, only sometimes overlap (2-σ) with other dates, or have relatively large standard deviations. An ugly date could be used in league with the good to build a chronology, but with additional dating such a date could be found bad. Therefore, my goal was to accept ages established as good, reject those found to be bad, and further analyze those found to be ugly. For example, a date of 25,160 ± 280 (AA-68669) from Kurtak-4 (cultural layer 1) was obtained on a piece of identified wood charcoal from a hearth

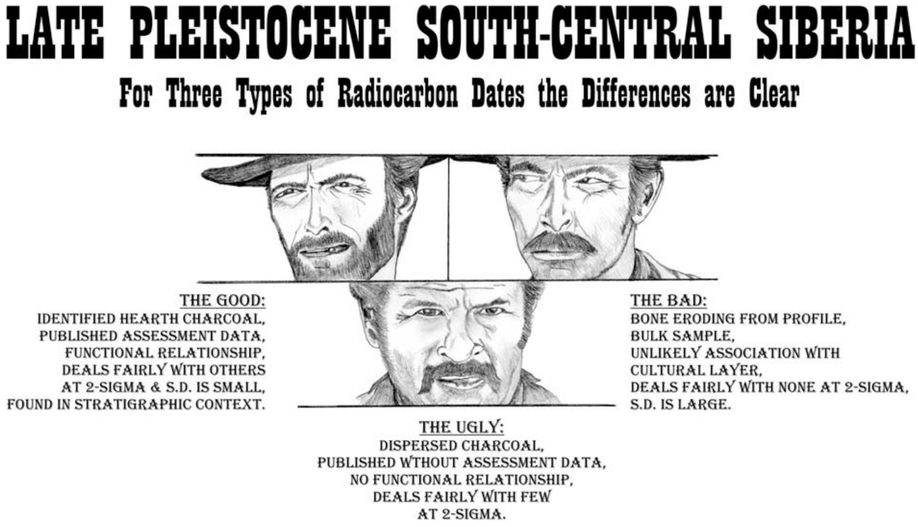

Fig. 2. The good, bad, and ugly. Placing radiocarbon-date types in perspective.

(conifer, likely *Picea* sp.). The sample, obtained by myself, identified by D. Rhode at the Desert Research Institute, and dated at the NSF-Arizona AMS Facility (full pretreatment and isotope data are reported and acceptable), is directly associated with cultural activities, overlaps (2-σ) with five other previously obtained dates from the cultural layer, has a relatively small standard error for an MIS-3 date, and fits within the site's stratigraphic sequence. Under the seven criteria, this sample received ranks of 3, 4, 3, 3, 4, 3, and 4, for a total score of 24. Therefore, this date was deemed good; in fact the only unequivocally good date for the entire Enisei River data set.

3.1.1. *The Good, Bad, and Ugly: results of criterion-based analysis*

A total of 34 MUP and LUP sites with 65 cultural occupations along the Enisei River have been ^{14}C dated. Thirty-five ^{14}C dates are from MUP sites and 126 are from LUP sites (Tables 1 and 2). These dates were analyzed following the good, bad, and ugly criteria (Table 3, Fig. 2), and the score for each date is presented in Tables 1 and 2.

For the MUP, 1 (3%) date was found to be good, 3 (8%) bad, and 31 (89%) ugly. For the LUP no dates were good, 27 (21%) bad, and 99 (79%) ugly. The majority of all ^{14}C-determinations were ugly (Figs. 3 and 4). These results are certainly disconcerting, even disheartening, but not surprising given that most of the dates were obtained by conventional ^{14}C analysis and typically published without detailed contextual information, only lab numbers and vague sample material information. Under the objective, criteria-based evaluation, most seemingly aberrant age estimates remained because their evaluation totals fell into the ugly category. In fact, one date possessing a 1-σ standard deviation of $\pm$5900 ^{14}C years was not rejected because it received an ugly rank. Unfortunately in the Enisei River case, we cannot simply accept only the good dates. By doing so, we would have no chronology. Short of rejecting all data and starting over, careful consideration of each of the ugly dates needs to be undertaken on a site-by-site basis.

3.2. *Further radiocarbon hygiene: evaluation of Ugly dates*

Since criterion-based evaluation left behind only one good and 130 ugly ^{14}C dates, I further evaluate remaining ugly dates on a site-by-site, issue-by-issue basis. Under this process, 32 ugly dates were rejected and 98 ugly dates were accepted. The decision to accept or reject a date was based on size of standard error, date concordance, and geological context.

3.2.1. *Middle Upper Paleolithic*

All dates reported from cultural layer 1 of Kurtak-4 were obtained on charcoal from a single hearth feature. Two of these, 24,000 $\pm$ 5900 (LE-4156) and 23,800 $\pm$ 900 (LE-4155), were rejected because they possess standard deviations >750 ^{14}C years. Their large age ranges have made these dates useless in developing a chronology. Four other dates, 27,770 $\pm$ 310 (AA-68668), 21,270 $\pm$ 160 (AA-72147), 20,690 $\pm$ 240 (AA-72146), and 17,740 $\pm$ 120 (AA-68670), were rejected because they do not overlap (2-σ) with the five remaining, relatively concordant dates. Of these remaining age determinations, 25,160 $\pm$ 280 (AA-68669), 24,890 $\pm$ 670 (LE-3357), 24,800 $\pm$ 400 (GIN-5350), and 24,170 $\pm$ 230 (LE-3351) overlap (2-σ); however, the fifth date, 23,470 $\pm$ 200 (LE-2833a), only overlaps (2-σ) with two of the other four dates. This determination (LE-2833a) could not be confidently rejected and was accepted, especially since

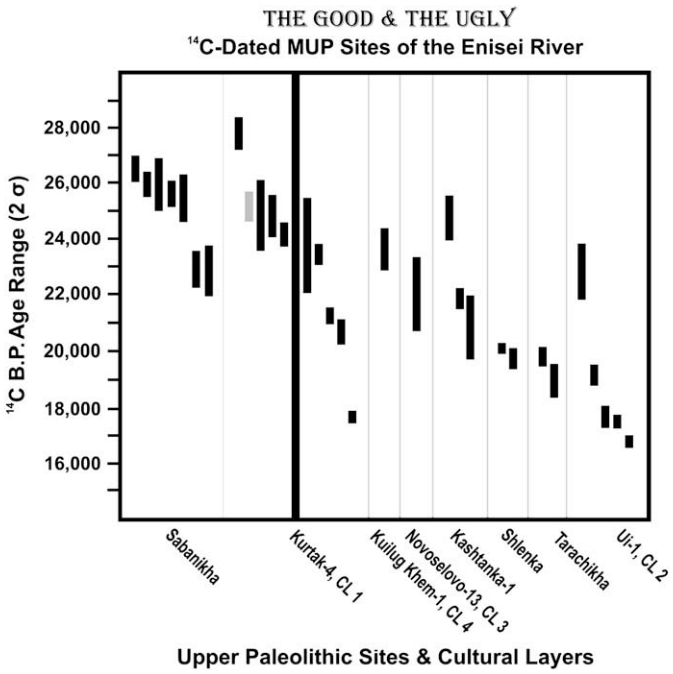

Fig. 3. Good and ugly MUP radiocarbon dates remaining after criteria evaluation. Bars represent 2-σ age ranges for dates (one gray bar represents the only good date). Notice obviously problematic dates that remained after criterion-based evaluation.

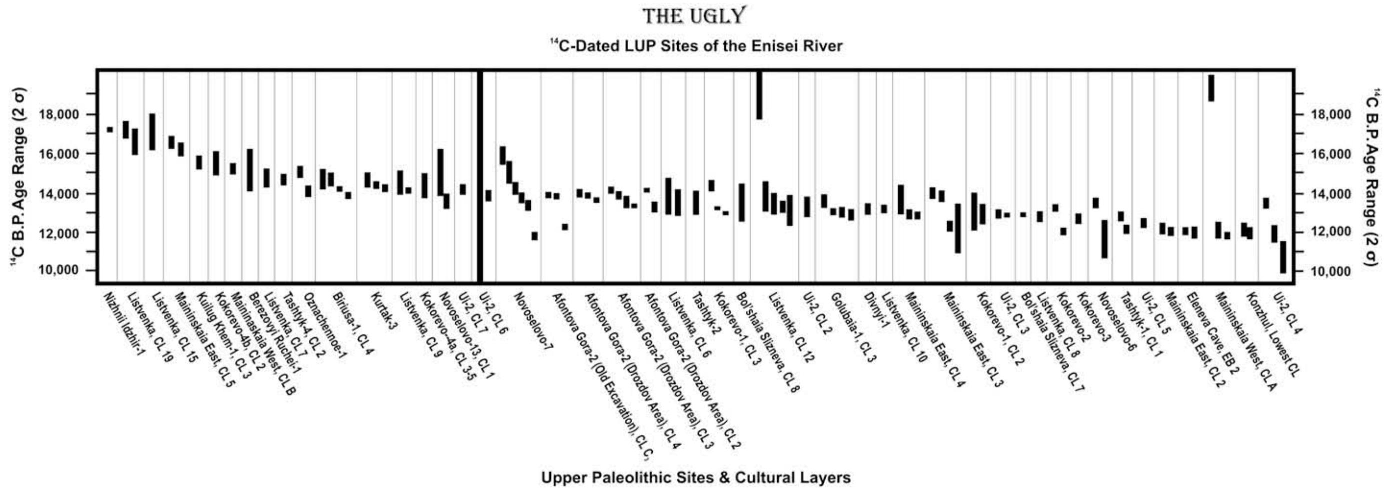

Fig. 4. Ugly LUP radiocarbon dates remaining after criteria evaluation. Bars represent 2-σ age ranges for dates. Notice obviously problematic dates that remained after criterion-based evaluation.

it fits the cultural layer's geological context (Lisitsyn, 2000). The cultural layer was stratigraphically positioned between the independently dated Kurtak Pedocomplex (36,000–26,000 ^{14}C BP) below and thin Trifonova Loess paleosol (24,000–21,000 ^{14}C BP) above (Bokarev and Martynovich, 1992; Drozdov et al., 1990, 1992; Frechen et al., 2005; Haesaerts et al., 2005; Zander et al., 2003), suggesting the accepted ^{14}C dates (26,000–23,000 ^{14}C BP) accurately reflect the age of occupation.

Seven ^{14}C dates have been obtained from the single cultural layer at Sabanikha. The oldest five, 26,520 ± 250 (AA-68665), 25,960 ± 240 (AA-68666), 25,950 ± 500 (LE-3747), 25,660 ± 250 (AA-68667), and 25,440 ± 450 (LE-4796), overlap (2-σ) with each other, and the youngest two, 22,930 ± 350 (LE-3611) and 22,900 ± 480 (LE-4701), overlap (2-σ) with each other, but the two clusters do not overlap. The first date-cluster likely reflects the age of the cultural occupation since it was well-represented by five determinations on different sample types (charcoal and bone) and obtained by both conventional and AMS ^{14}C methods, while the two younger dates were on dispersed charcoal obtained through conventional methods. Nevertheless, because the cultural layer was nearly 50-cm thick in places (Lisitsyn, 2000), it is possible that the other date-cluster could represent a second, later occupation.

One ugly date from Kashtanka-1 (cultural layer 1), 24,805 ± 425 (SOAN-2853), was rejected because it is not concordant with the other two ^{14}C assays, 21,800 ± 200 (IGAN-1049) and 20,800 ± 600 (GIN-6968), from the cultural layer, and instead is concordant (2-σ) with two dates from underlying geological stratum 10 (Drozdov et al., 1990).

Two ugly dates from Tarachikha obtained on mammoth bone (19,850 ± 180 [LE-3821] and 18,930 ± 320 [LE-3834]) and two

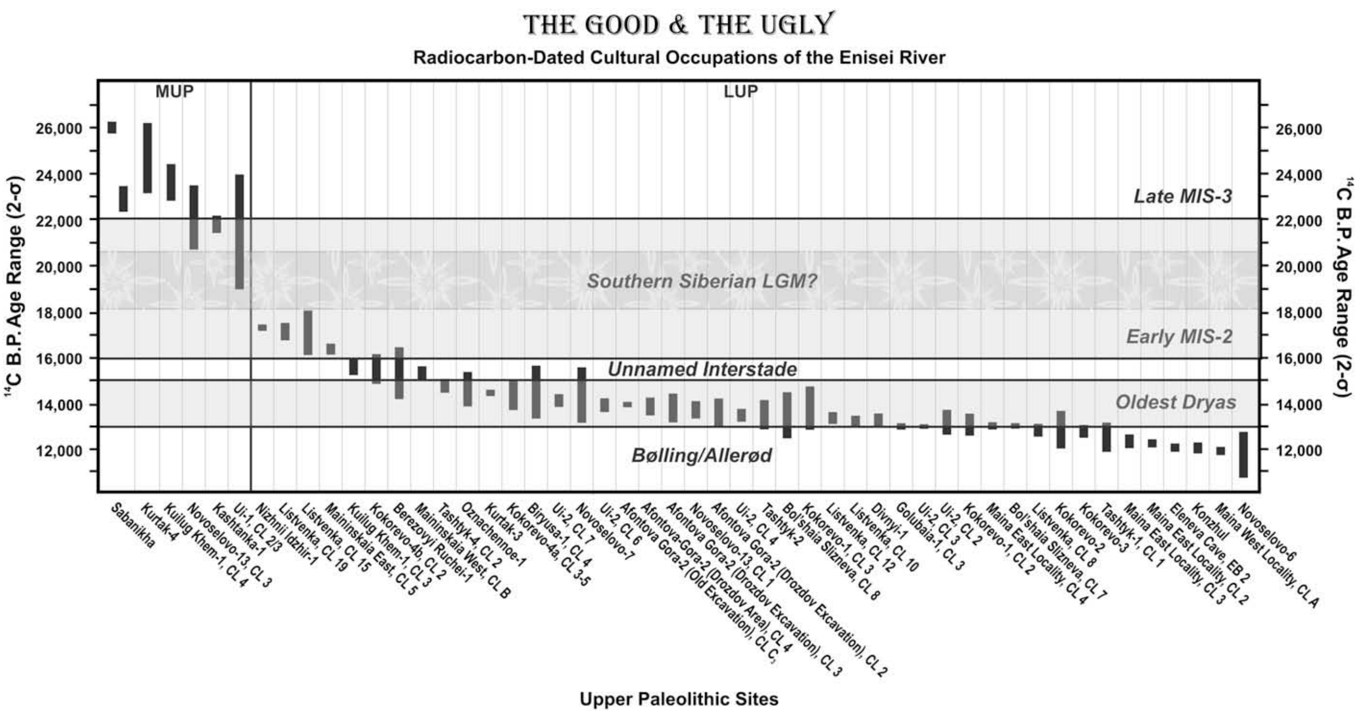

Fig. 5. Radiocarbon chronology for the MUP and LUP of the Enisei region. Bars represent 2-σ age ranges corresponding to data presented in Table 4.

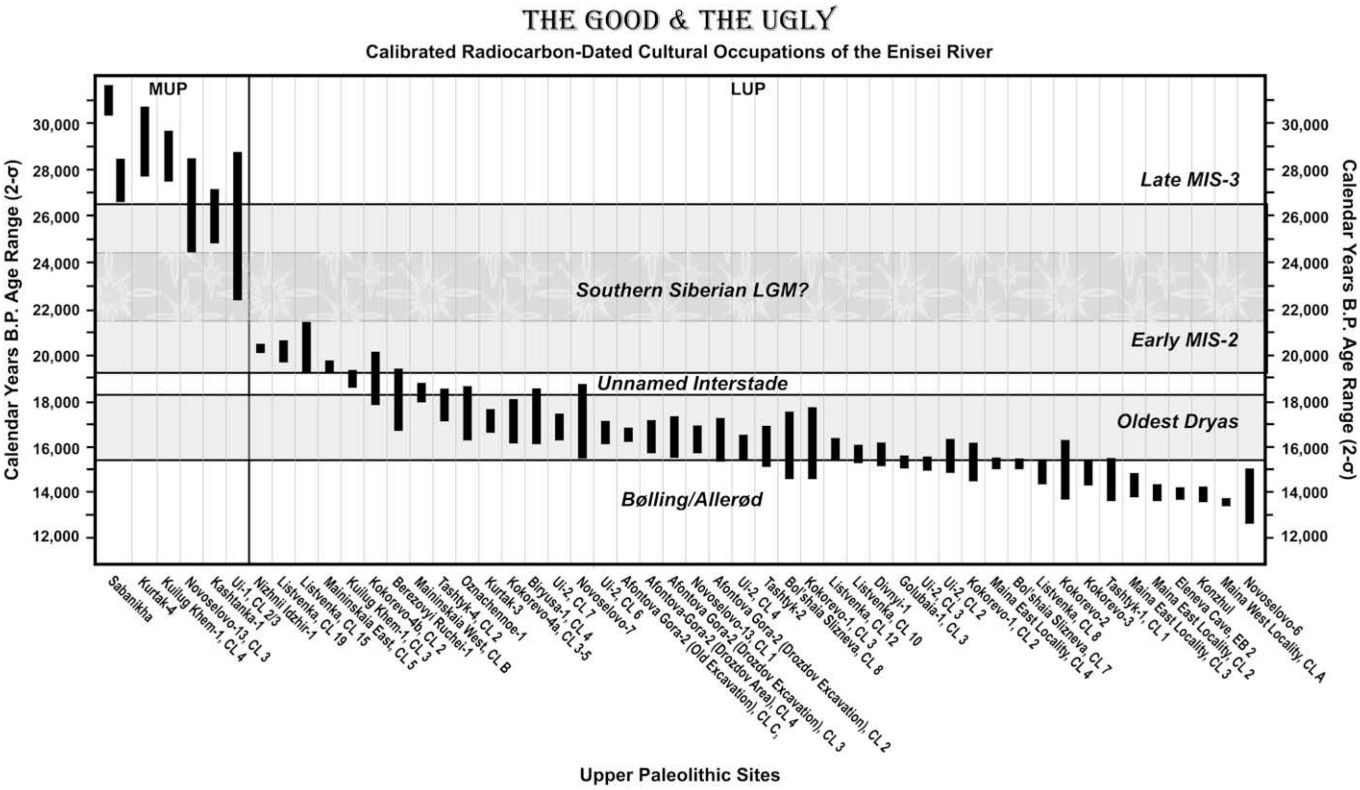

Fig. 6. Calibrated radiocarbon chronology. Bars represent 2-σ age range in calendar years.

from Shlenka obtained on mammoth tusk (20,100 ± 100 [GIN-2863]) and a mammoth-bone projectile point (19,700 ± 200 [GIN-2861]) were rejected because they are surface finds. Three of these dates (LE-3821, LE-3834, and GIN-2863) are reported with no taphonomic indicators demonstrating a direct tie to the cultural remains at the site (Iamskikh and Iamskikh, 1992; Lisitsyn, 2000). The other date (GIN-2861), obtained on the bone point from Shlenka, could be related to the artifact layer at the site. We cannot, however, unequivocally know since it is possible the surface find was left behind by a hunter who visited the site after having mined the bone from some natural bone accumulation dating to 19,700 ^{14}C BP. Clearly, dates on surface finds are highly problematic and often unreliable. Following this evaluation, no dates from either Tarachikha or Shlenka were found reliable and accepted.

Of the five age determinations obtained from Ui-1 (cultural layer 2), only two dates, 22,830 ± 530 (LE-4189) and 19,280 ± 200 (LE-4257), were accepted, and the other three dates, 17,690 ± 210 (AA-38054), 17,520 ± 130 (LE-3359), and 16,760 ± 120 (LE-3358) were rejected. Frost wedges were found penetrating the cultural layer from above (Vasil'ev, 1996), which may indicate that the site was inhabited just prior to the onset of LGM conditions. Further, the cultural layer is positioned within sediments of a fluvial terrace assigned to MIS-3 (Vasil'ev, 1996). Lithic remains from the cultural layer are characteristically MUP, further indicating a late MIS-3 habitation of the site (Graf, 2008; Vasil'ev, 1996, 2000). Both geological and archaeological data indicate the site dates to the very end of MIS-3.

Two single ^{14}C dates for MUP cultural layers were not rejected because they come from multilayered sites and are found in logical chronostratigraphic sequences relative to their stratigraphic positions (Lisitsyn, 2000; Semenov et al., 2005). These included 23,600 ± 400 (LE-6899) from Kuilug Khem-1 (cultural layer 4) and 22,000 ± 700 (LE-3739) Novoselovo-13 (cultural layer 3).

3.2.2. Late Upper Paleolithic

One date of 19,300 ± 350 (AA-38055) from Maininskaia West (cultural layer A3) was rejected because it does not overlap (2-σ) with other dates (Table 1) from the cultural layer, and it falls outside the otherwise straight-forward chronostratigraphic sequence for the site, including the date of 15,200 ± 150 (LE-2383) from cultural layer B. Two dates of 13,900 ± 150 (LE-2149) and 12,330 ± 150 (LE-2149) from Maininskaia East (cultural layer 3) were rejected because they do not overlap (2-σ) with other dates from the cultural layer (though both were obtained from the same bone piece that produced one of the concordant ages) and do not correspond with the rest of the site's chronostratigraphic sequence (Table 1).

One date of 14,310 ± 3,600 (LE-3717) from Ui-2 (cultural layer 6) was rejected because it has an unacceptably large standard deviation. One date of 12,440 ± 130 (AA-60037) from Ui-2 (cultural layer 5) was rejected since it is a single age determination for this layer and falls outside an otherwise acceptable chronostratigraphic sequence for the site. Two dates of 11,979 ± 230 (LE-3609) and 10,760 ± 420 (LE-3713) from Ui-2 (cultural layer 4) were rejected because they fall out of the site's chronostratigraphic sequence. The accepted ages for Ui-2 (Table 1) better conform with stratigraphic interpretations since they came from periglacial sediments assigned to the Older Dryas interval (Vasil'ev, 1996).

One date of 13,650 ± 180 (LE-1101 g) from Golubaia-1 (cultural layer 3) was rejected because it does not overlap (2-σ) with the other two concordant dates obtained on the same bone piece (Table 1).

The date of 13,570 ± 140 (LE-5045) from Novoselovo-6 was rejected because it does not overlap (2-σ) with the other date of 11,600 ± 500 (GIN-403) from the site, and its stratigraphic position within a paleosol suggests the cultural layer was deposited during interstadial (i.e., Allerød) and not stadial (i.e., Oldest Dryas) times (Abramova, 1979b).

Table 4
Pooled means of accepted ^{14}C dates (Overlapping at 2-σ).

Site[a]	Lab number	Material	Age estimate	Pooled mean[a]
MUP				
Sabanikha				
CL	AA-68665	Dispersed charcoal	26,520 ± 250	25,990 ± 130
CL	AA-68666	Dispersed charcoal	25,960 ± 240	
CL	LE-3747	Bone	25,950 ± 500	
CL	AA-68667	Dispersed charcoal	25,660 ± 250	
CL	LE-4796	Dispersed charcoal	25,440 ± 450	
CL	LE-3611	Dispersed charcoal	22,930 ± 350	22,920 ± 280
CL	LE-4701	Dispersed charcoal	22,900 ± 480	
Kashtanka-1				
Str 9/CL	IGAN-1049	Dispersed charcoal	21,800 ± 200	21,700 ± 190
Str 9/CL	GIN-6968	Hearth charcoal	20,800 ± 600	
LUP				
Maininskaia West				
CL A1-A3	LE-3019	Dispersed charcoal	11,700 ± 100	11,770 ± 90
CL A1	LE-4255	Bone	12,110 ± 220	
Mainainskaia East				
CL 5	LE-2135	Bone	16,540 ± 170	16,370 ± 120
CL 5	LE-2135	Bone	16,176 ± 180	
CL 4	LE-4251	Bone	13,690 ± 390	12,960 ± 80
CL 4	LE-2133	Bone	12,980 ± 130	
CL 4	LE-2133	Bone	12,900 ± 100	
CL 3	LE-2149	Bone	12,330 ± 150	12,330 ± 150
CL 3	LE-4252	Bone	12,120 ± 650	
CL 2-1	LE-2300	Bone	12,280 ± 150	12,180 ± 90
CL 2-1	LE-2300	Bone	12,120 ± 120	
Ui-2				
CL 3[a]	AA-38048	Bone	12,970 ± 120	12,900 ± 50
CL 3	AA-38047	Bone	12,880 ± 60	
Golubaia-1				
CL 3	LE-1101	Hearth charcoal	13,050 ± 90	13,000 ± 70
CL 3	LE-1101v	Bone	12,980 ± 140	
CL 3	LE-1101b	Bone	12,900 ± 150	
Kokorevo-1				
CL 2	IGAN-103	Bone	13,100 ± 500	12,980 ± 240
CL 2	LE-526	Hearth charcoal	12,940 ± 270	
Novoselovo-13				
CL 1	LE-4896	Bone (reindeer)	15,030 ± 620	13,760 ± 190
CL 1	LE-4805	Bone (reindeer)	13,630 ± 200	
Kurtak-3				
EB 1, CL	LE-1456	Hearth charcoal	14,390 ± 100	14,370 ± 70
EB 2, CL	GIN-2101	Hearth charcoal	14,600 ± 200	
EB 2, CL	LE-1457	Hearth charcoal	14,300 ± 100	
Konzhul				
LUP CL	SOAN-4954		12,160 ± 175	12,060 ± 120
LUP CL	SOAN-4953		11,980 ± 155	
Listvenka				
CL 19	SOAN-5084	Bone (mammoth)	17,200 ± 230	17,030 ± 190
CL 19	SOAN-3734	Dispersed charcoal	16,640 ± 350	
CL 12	SOAN-3833	Bone (bison)	13,910 ± 400	13,350 ± 130
CL 12	SOAN-3733	Dispersed charcoal	13,470 ± 285	
CL 12	SOAN-4868	Bone (bison)	13,260 ± 160	
CL 12	GIN-6965	Hearth charcoal	13,100 ± 410	
Eleneva Cave				
EB 2	SOAN-3309	Dispersed charcoal	12,085 ± 105	12,070 ± 90
EB 2	SOAN-3308	Dispersed charcoal	12,040 ± 160	
Afontova Gora-2, Main excavation				
D2	AA-68663	Dispersed charcoal	13,970 ± 80	13,920 ± 60
D2	AA-68664	Dispersed charcoal	13,870 ± 80	

[a] Pooled mean of dates given at 1-σ standard deviation.

For Novoselovo-7, dates of 15,950 ± 120 (LE-4802) and 11,700 ± 110 (AA-72561) were rejected because they do not overlap with other dates that are more concordant with stratigraphic context. The date of 15,000 ± 300 (GIN-402) overlaps (2-σ) with only one (14,220 ± 170 [LE-4803]) of the other concordant dates (13,800 ± 140 [AA-68674] and 13,480 ± 140 [AA-68672]); however, this date along with the other three corresponds to the geological context of the cultural layer and could not be rejected. Rejected dates correlate with two possible interstadial events, while the cultural layer likely was deposited during stadial (Oldest Dryas) times, suggested by its position in heavily cryoturbated, periglacial deposits (Abramova, 1979b).

Six ugly dates were rejected from Listvenka (Table 1). In cultural layer 12, the date of 19,000 ± 660 (Beta-58391) is not concordant with four other determinations from that layer. In cultural layer 9, dates of 14,580 ± 320 (SOAN-3834) and 14,170 ± 80 (GIN-6967) overlap (2-σ) with each other, but do not fit the site's chronostratigraphic sequence. Further, dates of 14,750 ± 250 (GIN-6092) from cultural layer 7 and 13,850 ± 485 (SOAN-3463) and 13,590 ± 350 (IGAN-1079) from cultural layer 6 are too old given the site's chronostratigraphic sequence. This is especially true since the four dates from cultural layer 12 (statistically the same age) post-date the early ages for cultural layers 7 and 6. Likely, the cultural layers were deposited in a logical sequence with cultural layer 12 dating to 14,000–13,000 ^{14}C BP, cultural layer 10 to 13,000 ^{14}C BP, and cultural layer 8 to 12,750 ^{14}C BP. This scenario seems more parsimonious than accepting all dates and a "flip-flopping" chronology.

The last date rejected, 12,280 ± 80 (AA-68662), is from Afontova Gora-2 (cultural layer C_3). It does not overlap with others from the cultural layer (Table 1), and it was obtained on dispersed charcoal from a 1-m^2 excavation unit (D1) adjacent to another 1-m^2 unit (D2) where the samples with the accepted dates originated. Cultural layer C_3 appears to have been a rather discrete cultural lens with an outside boundary that horizontally cut across unit D1 (Astakhov, 1999). Likely, the charcoal sample from D1 was collected outside the cultural lens near the contact between cultural layer C_3 and lower stratum D. Age estimates obtained by Drozdov and Artem'ev's (1997, 2007) excavations of another locality within the site range in age from about 14,000 to 13,000 ^{14}C BP, falling inline with the 13,900 ^{14}C BP dates from D2. Further, three dates were obtained on dispersed charcoal from cultural layer 4 of the Drozdov and Artem'ev (1997, 2007) excavation. The dates of 14,070 ± 110 (SOAN-3075) and 13,650 ± 70 (GIN-7540) do not overlap (2-σ) with each other, but both overlap with the third date of 13,930 ± 80 (GIN-7541), and their difference is only 60 ^{14}C years. In cultural layer 3, two dates, 14,300 ± 95 (SOAN-3077) and 13,990 ± 110 (GrN-22274), overlap (2-σ), and two other dates, 13,600 ± 80 (SOAN-5123) and 13,350 ± 60 (GIN-7539), also overlap (2-σ). The two sets, however, do not overlap with each other, but are only separated by 300 ^{14}C years. Two age estimates on dispersed charcoal from cultural layer 2, 14,200 ± 60 (GrA-5556) and 13,330 ± 140 (GIN-7542), do not overlap (2-σ). Geologically, however, all three cultural layers were likely deposited during stadial times and all nine dates fit within the Oldest Dryas interval; therefore, they were accepted.

One date from Kokorevo-1, cultural layer 3, 14,450 ± 150 (LE-628), does not overlap (2-σ) with the other dates from this layer (Table 1). Geologically, the layer was deposited during stadial times (Abramova, 1979b). All three dates fall into the Oldest Dryas age range; therefore, all three were accepted. Both dates from cultural layer 2 (Table 1) were accepted since they overlap (2-σ) and fit the site's geological and stratigraphic sequence. At Biriusa-1, one (13,840 ± 90 [GIN-8075]) of four dates from cultural layer 4 does not overlap (2-σ) with the others (Table 1), but since its age falls within the Older Dryas interval, matching the periglacial stratigraphic context of the cultural layer (Kuzmina and Sinitsyna, 1995; Lisitsyn, 2000), it was accepted.

Two dates, 13,330 ± 100 (GIN-90) and 12,090 ± 100 (LE-4812), were obtained from the Kokorevo-2 cultural layer. The cultural layer had two horizons and was associated with a paleosol (Abramova, 1979a; Tseitlin, 1979). Its association with a paleosol suggests the layer was deposited during an interstadial, and both ages generally fit the Bølling interval. Although these samples lack specific provenience information so they could reflect two occupation events, neither date could be confidently rejected.

From the cultural layer of Oznachennoe-1, two age estimates, 15,020 ± 150 (LE-1404) and 14,100 ± 150 (LE-1404), were obtained on the same bone piece. Geologically, cultural remains were deposited during stadial times (Astakhov, 1986), and both dates fall within the Oldest Dryas interval, so both were accepted. At Tashtyk-1, the only two reported dates from cultural layer 1, 12,880 ± 130 (LE-4980) and 12,180 ± 120 (LE-771), were obtained on bone and dispersed charcoal, respectively. Their stratigraphic position suggests the site was occupied during an interstadial, and both determinations fall within the Bølling interval (Abramova, 1979a; Tseitlin, 1979), so both were accepted. The two dates of 15,030 ± 620 (LE-4896) and 13,630 ± 200 (LE-4805) from Novoselovo-13 (cultural layer 1) appear discordant; however, because the cultural layer was deposited during stadial times (Lisitsyn, 2000) and both dates fall within the Oldest Dryas interval, both were accepted. All three of the remaining ugly dates from Kurtak-3 (Table 1) were accepted because they overlap (2-σ) and their stratigraphic position suggests they were deposited during the Oldest Dryas (Lisitsyn, 2000). The two ugly dates from Konzhul were accepted because they overlap (2-σ), though not much is known of the cultural layer's geological context. The two remaining ugly dates from Eleneva Cave were tentatively accepted since they overlap (2-σ), but like Konzhul their stratigraphic situation is not well understood (Vasil'ev et al., 2005b).

Given the recurrent difficulties in reliably dating an occupation event when more than one age estimate is available, occupations with single dates can be very problematic. In several instances, however, I found no reason to reject single dates when their stratigraphic contexts complemented their ages. With further testing such dates may be found to accurately reflect the age of the cultural occupation. Accepted dates in this category include 17,200 ± 70 (LE-1984) from Nizhnii Idzhir, 13,550 ± 320 (LE-4801) from Tashtyk-2, 14,700 ± 150 (GIN-262) from Tashtyk-4, 12,690 ± 140 (LE-629) from Kokorevo-3, 14, 320 ± 330 (LE-469) from Kokorevo-4a (cultural layers 5-3), 15,460 ± 320 (LE-540) from Kokorevo-4b (cultural layer 2), 13,220 ± 150 (LE-4806) from Divnyi-1, and 15,210 ± 560 (LE-4895) from Berezovyi Ruchei-1. Three single ^{14}C dates for MUP cultural layers from multilayered sites were accepted because they are found in logical chronostratigraphic sequences relative to their stratigraphic positions (Orlova, 1995; Semenov et al., 2005), including 15,500 ± 180 (LE-6901) from Kuilug Khem-1 (cultural layer 3) and 13,540 ± 500 (SOAN-3315) and 12,930 ± 60 (SOAN-3009) from Bol'shaia Slizneva (cultural layers 8 and 7, respectively).

After second evaluation of 130 ugly dates, 32 were deemed bad and rejected, 98 remained ugly, but could not be comfortably rejected. In the end a total of 62 dates were rejected, while 99 were accepted (Tables 1 and 2) and used to develop the Enisei River MUP and LUP chronology proposed below.

4. Toward a reliable chronology: the Good and Ugly

A total of 99 age determinations (18 MUP and 81 LUP) were thus used to develop a chronology of dated cultural occupations in the Enisei region (Figs. 5 and 6; Table 4). Each cultural layer is considered to represent an individual cultural occupation of a given site. To provide a single age range for an occupation, a pooled mean for each cultural occupation was calculated for ^{14}C dates that overlapped (2-σ). Pooled means were not calculated for occupation layers that still contained ugly outliers. In these cases a single age range was given that incorporated the entire 2-σ range of possible dates for the layer. Although precision was sacrificed in these cases, accuracy may not have been. Also, in instances where a cultural layer possessed only one ^{14}C date, the entire 2-σ age range for that date is shown. The resulting chronology includes seven MUP and 44 LUP cultural occupations (Fig. 5).

Dated cultural occupations were calibrated (Fig. 6). Since 21,300 ^{14}C BP has been established as the maximum limit for reliable ^{14}C calibration by the internationally accepted IntCal04 calibration curve (Reimer et al., 2004), this curve was used to calibrate all dates $\leq$21,300 ^{14}C BP. To be able to include all dates in the calibrated chronology, however, dates older than 21,300 ^{14}C BP were calibrated using the CalPal 2007 HULU Curve (Bard et al., 2004; Fairbanks et al., 2005; Hughen et al., 2006; Voelker et al., 2000; see Danzeglocke et al., 2007, www.calpal-online.de).

The revised ^{14}C and calibrated chronologies show MUP occupations at the boundary between MIS-3 and MIS-2, dating from about 26,100 to 20,800 ^{14}C ($\sim$31,000-24,800 cal) BP. With the exception of one ugly Ui-1 date, there appears to be a hiatus from about 20,800 to 17,200 ^{14}C ($\sim$24,800–20,700 cal) BP during the climatic minimum (LGM), with ^{14}C-dated cultural occupations re-entering the record at about 17,200 ^{14}C (20,700 cal) BP. During the late glacial most LUP occupations date to the Oldest Dryas cold interval (roughly 15,000–13,000 ^{14}C [18,300–15,400 cal] BP), while far fewer occupations date to warm oscillations after the LGM.

5. Conclusions

In developing a reliable chronology for MUP and LUP occupations of the Enisei River valley, 14 new AMS age determinations were reported, and these new dates coupled with 147 previously reported ^{14}C dates were evaluated in a two-step process. Initially a set of seven evaluation criteria was used in an attempt to objectively assess individual dates within existing site chronologies. Many discordant dates, however, remained. In this case study, criterion-based evaluation (such as that used by Pettitt et al. (2003)) did not work by itself; it did not separate clearly aberrant dates from those potentially reliable. Therefore, each remaining ^{14}C sample was re-evaluated, this time considering geological and archaeological contexts on a site-by-site and date-by-date basis. The resulting chronology included 99 dates from 51 cultural occupations spanning 26,000–11,500 ^{14}C (31,000–13,000 cal) BP.

The revised chronology provided above suggests MUP foragers occupied the Enisei River valley between about 26,100 and 20,800 ^{14}C ($\sim$31,000–24,800 cal) BP, with at least seven cultural occupations represented. Between 20,800 and 17,200 ^{14}C (24,800–20,700 cal) BP, there are no cultural occupations that reliably date to this time. Other regions in Siberia, including the Transbaikal, Angara, and western Siberia, may have experienced a similar drop in the frequency of dated occupations during the LGM (Dolukhanov et al., 2002; Goebel, 2002; Goebel et al., 2000). Likewise, others have reported a possible hiatus or at least major decrease in human populations at this time elsewhere in northern Eurasia. On the Eastern European Plain, ^{14}C-dated, Upper Paleolithic occupation frequencies have a bimodal distribution that straddles the LGM, with peaks in occupation just prior to and following this cold maximum (Sinitsyn et al., 1997). Multicomponent sites such as Molodova-5 (Dnestr River, Ukraine/Moldova border) and the Kostenki complex (Don River, Russia) have Gravettian MUP and Epigravettian LUP cultural layers stratigraphically separated by sterile loess sediments (sometimes greater than 50 cm in thickness) that date between about 20,000 and 18,000 ^{14}C (24,000–21,700 cal) BP, suggesting possible LGM abandonment of the region (Chertysh, 1987; Dennell, 1983; Dolukhanov et al., 2001; Hoffecker, 2002a, b; Klein, 1973; Praslov and Rogachev, 1982; Soffer, 1985).

Possibly, as climatic conditions deteriorated with the onset of the LGM, hunter-gatherers living in south-central Siberia left the region or at least their populations dwindled to archaeologically unrecognizable levels. These data support Goebel's (1999, 2002; see also Dolukhanov et al., 2002; Graf, 2005) position that Upper Paleolithic peoples abandoned parts of northern Asia during the LGM and, therefore, do not support Kuzmin's (2008) (Kuzmin and Keates, 2005a,b) assertion that human populations were maintained in all areas of Siberia during this time. With more excavations and dating, however, it could be found that the LGM-gap in the Enisei may be filled.

LUP sites appear by about 17,200 ^{14}C (20,700 cal) BP, as climate began to ameliorate after the LGM, and then increase in number thereafter. Perhaps foragers re-entered the region at this time. Given recent work in Sakhalin and Japan that suggests human populations may not have waned in these regions (Izuho and Takahashi, 2005; Nakazawa et al., 2005; Vasilevskii, 2005), it is reasonable to suggest that a re-colonization event originated in maritime eastern Asia, with humans spreading west and north following the LGM (Graf, 2008). During the late glacial, LUP foragers were present throughout time; however, if frequency of dated cultural occupations is a reasonable proxy of population levels, populations in the Enisei region seem to have increased during the cold Older Dryas interval. The pattern of increased human population in colder climates is interesting and unexpected, though Mason et al. (2001) recognized a similar pattern for microblade-bearing Denali sites in Alaska. Perhaps late glacial foragers found the Enisei River valley between 52° and 56°N latitude more hospitable during colder episodes. LUP foragers who had migrated further north into central and northern Siberia after the LGM may have moved back south into refugia during cold intervals. Paleontological data suggest a dip in large mammalian populations in northern Siberia and Beringia during this time as well (Guthrie, 2006; Sher et al., 2005). Perhaps humans were following the ebb and flow of mammalian populations (e.g., reindeer, bison), who also may have found refuge in relatively warm regions of southern Siberia.

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