Modern Human Colonization of the Siberian Mammoth Steppe: A View from South-Central Siberia

Kelly E. Graf

Abstract Was the transition from the middle Upper Paleolithic (MUP) to late Upper Paleolithic (LUP) in Siberia the result of gradual, in situ cultural change or abrupt change that resulted from multiple recolonization attempts? Past studies have primarily focused on chronology and typology in attempts to reconstruct culture histories. As a result reconstruction of hunter-gatherer ecology has been limited to broad overviews and generalizations. Questions regarding the processes of human colonization have largely remained unanswered. Explaining the differences between MUP and LUP behavioral adaptations and decision-making in the Siberian mammoth steppe is critical to achieving full understanding of the process of human colonization of the North during the late Pleistocene. This study uses both radiocarbon and lithic technological data from MUP and LUP sites located in the Enisei River valley of south-central Siberia to address the problem from a more comprehensive behavioral perspective. Chronological data demonstrate the MUP and LUP in the Enisei region were separated by a 4000-year gap straddling the LGM, while lithic data suggest MUP foragers before the LGM were making different technological provisioning decisions than LUP foragers after the LGM. Results of this study indicate that the Siberian mammoth steppe was colonized during multiple dispersal events.

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A long-time concern in Paleolithic archaeology has been to define large-scale transitions from one archaeological phase to another (e.g., Middle to Upper Paleolithic Transition) (Adams, 1998; Akazawa et al., 1998; Goebel, 1993; Klein and Edgar, 2002; Hoffecker, 2002). These large transitions are interesting and important in our understanding of human biocultural evolution; however, what about the countless small-scale transitions that are commonly neglected?

It is often an accumulation of small transitions that lead to the large changes we see in the archaeological record of hominid behavior and biocultural evolution (Kuhn, 2006). This chapter focuses on a small-scale transition: the "transition" from the middle Upper Paleolithic (MUP) to late Upper Paleolithic (LUP) in south-central Siberia. The MUP to LUP transition is a much less known, but not any less significant, transition that occurred in the evolution of modern human behavior, allowing modern humans to successfully spread into the periglacial regions of the North (Straus, 1995; Goebel, 1999, 2002).

Modern Human Dispersal into Northern Asia

Modern humans dispersed into temperate regions of the globe such as Australia and Europe rather rapidly (Gamble, 1994; Klein, 2000; Lahr and Foley,

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1994); however, their expansion into empty, periglacial regions of northern Eurasia may have been an episodic process, taking tens of thousands of years (Goebel, 1999). Upper Paleolithic settlement of northern landscapes was constrained by extreme environmental challenges that required the development of complex technological and behavioral adaptations (Binford, 1990; Hoffecker, 2002; Oswalt, 1987). Today, the Arctic extends south to latitudes between 70°N and 60°N (Krupnik, 1993; Young, 1989); however, during the late Pleistocene, arctic conditions extended much further to the south—as far as 50°N (Velichko, 1984; Vorob'eva and Medvedev, 1984; Zykina, 1999, 2003). The climate across northern Eurasia during the late Pleistocene would have been extremely continental and cold, producing a Holarctic (often treeless) biome that sustained large herbivorous faunal populations; a biome often referred to as steppe-tundra (Vereshchagin and Baryshnikov, 1982; Yurtsev, 1982) or mammoth steppe (Guthrie, 2001) (Fig. 1). Consequently, the dispersal of modern humans into the mammoth steppe was a significant event in our past—one involving important changes in technology and behavior.

What We Know About the MUP and LUP in Siberia

Hundreds of archaeological sites with Paleolithic cultural occupations are known in Siberia. Many sites are not dated by absolute techniques, but are assigned to the Paleolithic based either on stratigraphic contexts and/or typological comparisons (e.g., Abramova et al., 1991; Astakhov, 1986). Of these, at least 100 sites have been dated by radiometric methods (Vasil'ev et al., 2002), and most are situated along major river drainages and occur south of 55°N latitude (Fig. 2).

Although several sites reported to have Lower Paleolithic artifacts have been offered as evidence for initial human populations in Siberia (Astakhov, 1986; Chlachula, 2001; Drozdov et al., 1990, 1992, 1999; Mochanov, 1988, 1993; Okladnikhov, 1972; Okladnikhov and Pospelova, 1982; Okladnikhov and Ragozin, 1984; Waters et al., 1997, 1999), the earliest unequivocal evidence comes from a handful of southern Middle Paleolithic sites dating from about 125,000 to 50,000 years ago, and located in relatively temperate regions (Abramova, 1984; Goebel, 1999; Powers, 1973). Based on lithic typology, these sites likely represent a far eastern incursion into the area by Neanderthals (Astakhov, 1990; Derevianko, 1998; Derevianko and Markin, 1990; Goebel, 1993; Goebel et al., 1993; Vasil'ev, 2001).

Southern Siberia was first settled by anatomically modern human populations, represented by early Upper Paleolithic industries, as early as 46,000 calendar years before present (cal) BP (Bazarov et al., 1982; Dolukhanov et al., 2002; Goebel, 1993, 1999, 2004a; Goebel and Aksenov, 1995; Goebel et al., 1993; Lbova, 1996; Muratov et al., 1982). Similar to earlier hominids, early modern humans do not seem to have penetrated subarctic Siberia. Modern human settlement of the subarctic did not transpire until about

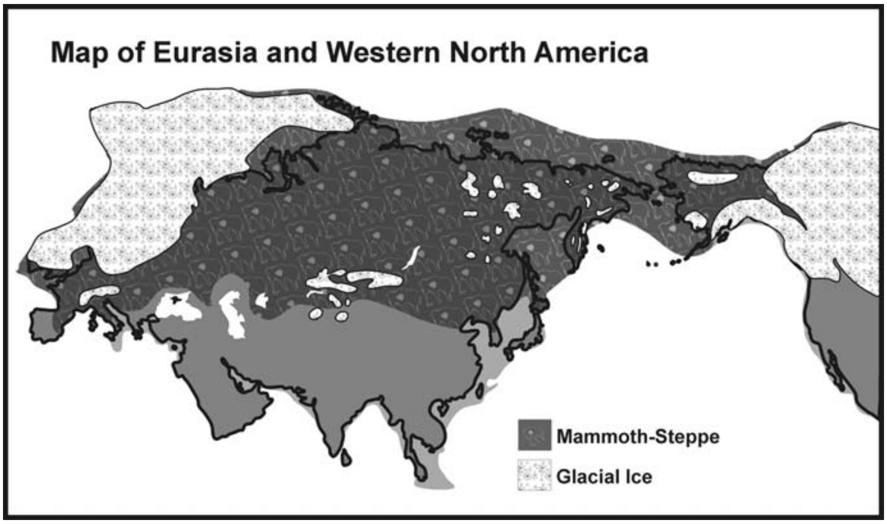

Fig. 1 Map of R. Dale Guthrie's mammoth steppe (after Guthrie, 1990)

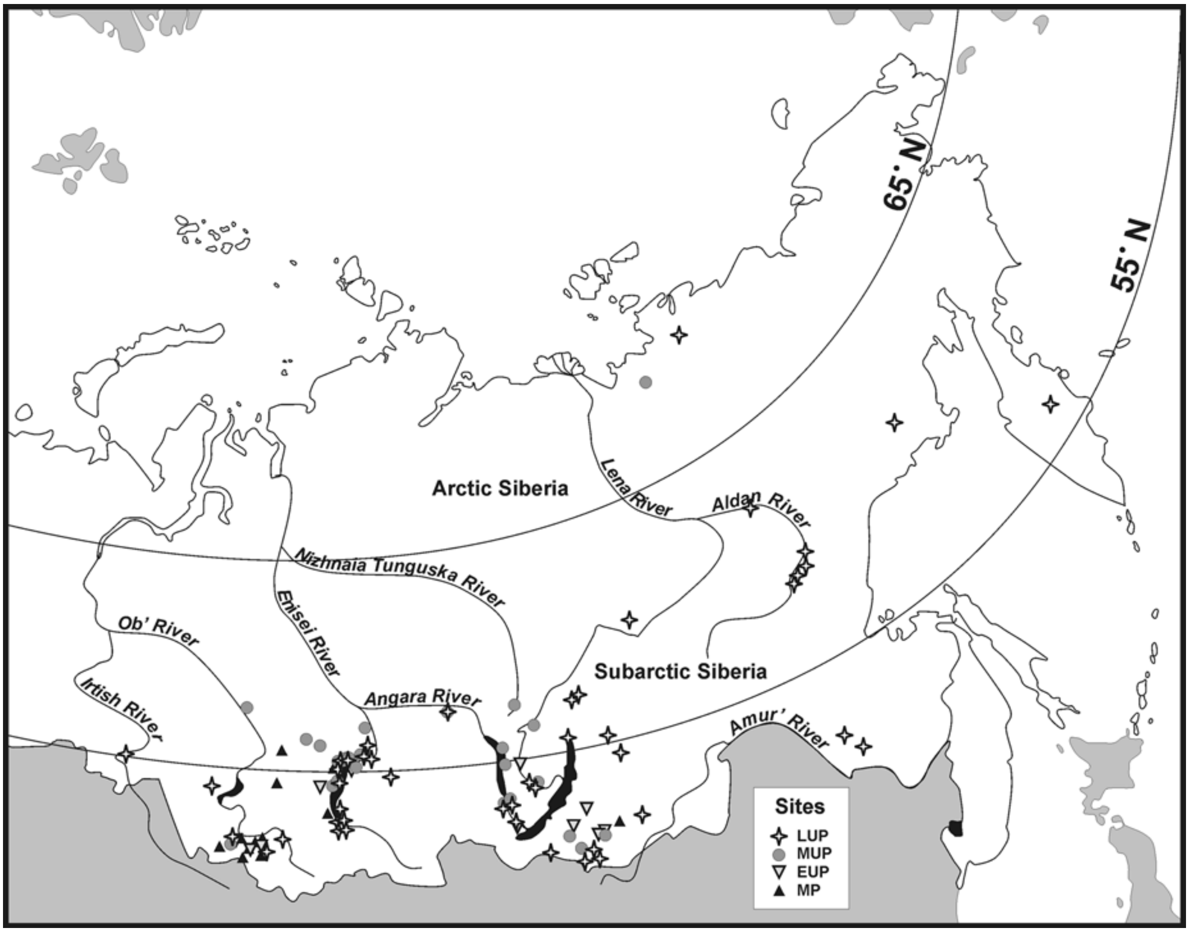

Fig. 2 Map of Siberia with locations of major paleolithic sites

33,000 cal BP, when MUP hunter-gatherers may have spread as far north as 71°N, as evidenced by the Yana RHS Upper Paleolithic site (Pitulko et al., 2004).

The MUP occupation of Siberia lasted for about 9,000–10,000 years (33,000–24,000 cal BP), and is represented by typical Upper Paleolithic technologies broadly similar to those found in other regions of Eurasia during this time period (Goebel, 1999; Vasil'ev, 1993, 2000). MUP technologies are characterized by flake and blade[1] production on fine-grained silicate raw materials (or toolstones) (Fig. 3). Blade size is variable, with small blades or bladelets being most common. Although formal microblade[2] technologies appear to be absent (Abramova, 1989; Goebel, 1999, 2002), some have argued that they were actually incipient in the MUP (Derevianko, 1998; Kuzmin and Keates, 2005a, b; Kuzmin and Orlova, 1998; Lisitsyn, 2000). Secondary reduction is characterized by unifacial, bifacial, and burin technologies, and tool forms include end scrapers, side scrapers, bifaces,[3] gravers, burins, and retouched

[1] MUP blade cores are typically of the informally produced, "flat-faced" blade core variety noted in early Upper Paleolithic sites of Siberia (Goebel, 1993). Only when they are heavily reduced do they take-on a subprismatic shape.

[2] Microblades are defined as very standardized, miniature blades measuring 8 mm or less in width and less than 20 mm in length with the width maintained along the entire length of the blade. Also, these are detached from specially prepared microblade cores (Abramova, 1971, 1979b; Anderson, 1970; Markin, 1986).

[3] Bifaces in MUP and LUP assemblages were not hand-axes. MUP bifaces may have been choppers, knives, or scrapers. LUP bifaces could have been projectile points, knives, scrapers, or wedge-shaped core performs.

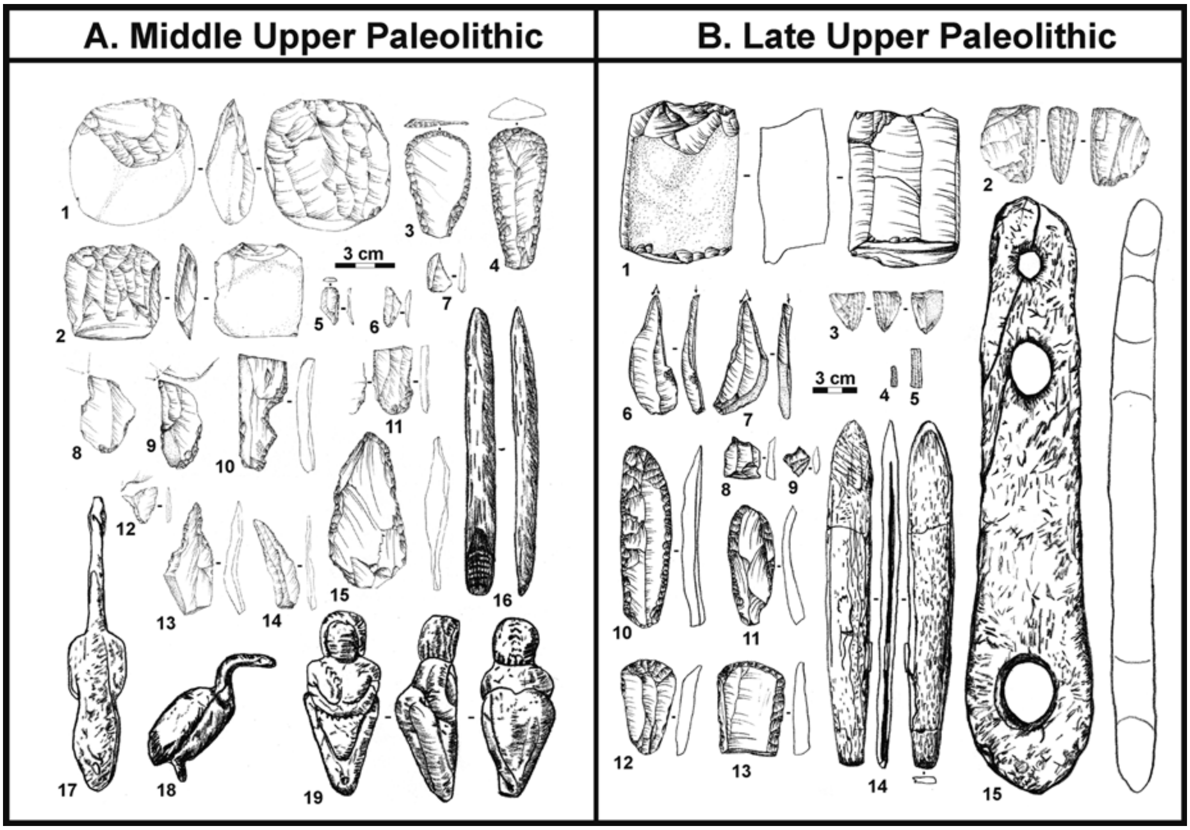

Fig. 3 Middle Upper Paleolithic (**A**) artifacts: flat-faced blade core (A.1); bladelet core (A.2); end scrapers (A.3–4); retouched bladelets (A.5–7); burins (A.8–9); notch (A.10); retouched blade (A.11); gravers (A.12–13); retouched blade-like flake (A.14); side scraper (A.15); bone point (A.16); ivory figurines (A.17–18: birds, A.19: Venus). A.1–4, A.9–10, A.15: Sabanikha (Enisei River); A.5–8, A.11–14: Afanas'eva Gora (Enisei River); A.17–19 Mal'ta (Angara River). (A.1–15 drawn by author; A.16 redrawn from Lisitsyn, 2000; A.17–19 redrawn from Abramova, 1995). Late Upper Paleolithic (**B**) artifacts: subprismatic blade core (B.1); wedge-shaped microblade core (B.2); *tortsovyi* microblade core (B.3), retouched microblade mid-sections (B.4–5); burins (B.6–7); gravers (B.8–9); side scrapers (B.10–11); end scrapers (B.12–13); slotted ivory point with intact microblade mid-section (B.14); ivory *bâton de commandement* (B.15). B.1–3, B.6–8, B.10–13: Kokorevo-1 (Enisei River); B.4–5: Kokorevo-2 (Enisei River); B.9: Kokorevo-3 (Enisei River); B.14–15: Listvenka (Enisei River). (B.1, B.6–8, B.10–13 redrawn from Abramova, 1979b; B.2–5 drawn by author; B.9 redrawn from Abramova, 1979a; B.14–15 redrawn from Akimova, et al. 2005)

blades and flakes. Osseous tools (e.g., awls, needles) and nonutilitarian artifacts (e.g., beads, figurines) are common. Faunal assemblages primarily include mammoth, reindeer, woolly rhinoceros, bison, horse, red deer, hare, wolverine, fox, and birds (Ermolova, 1978; Vasil'ev, 2003b). Large semisubterranean dwellings (often slab-lined with storage pits and hearths) were constructed, and a wide variety of site types are reported (Abramova, 1989, 1995; Abramova et al., 1991; Bokarev and Martynovich, 1992; Ermolova, 1978; Medvedev, 1982; Vasil'ev, 2000, 2003a).

During the Last Glacial Maximum (LGM), roughly 23,500–19,000 cal BP (Bowen et al., 2002; Owen et al., 2002; Yokoyama et al., 2000), large ice sheets expanded across northwestern Eurasia, climatic conditions were extremely harsh, and large mammal populations declined (Guthrie, 2003; Svendsen et al., 2004). Sites dating to this time are rare in Siberia and central Asia (Davis, 1998; Davis and Ranov, 1999; Dolukhanov et al., 2002; Goebel, 1999; Graf, 2005; Surovell et al., 2005), suggesting possible abandonment of the north by humans (Fig. 4). This idea has been rejected by some who argue that site density decline could be the result of sampling biases and postdepositional processes, and sufficient evidence indicates sustained settlement

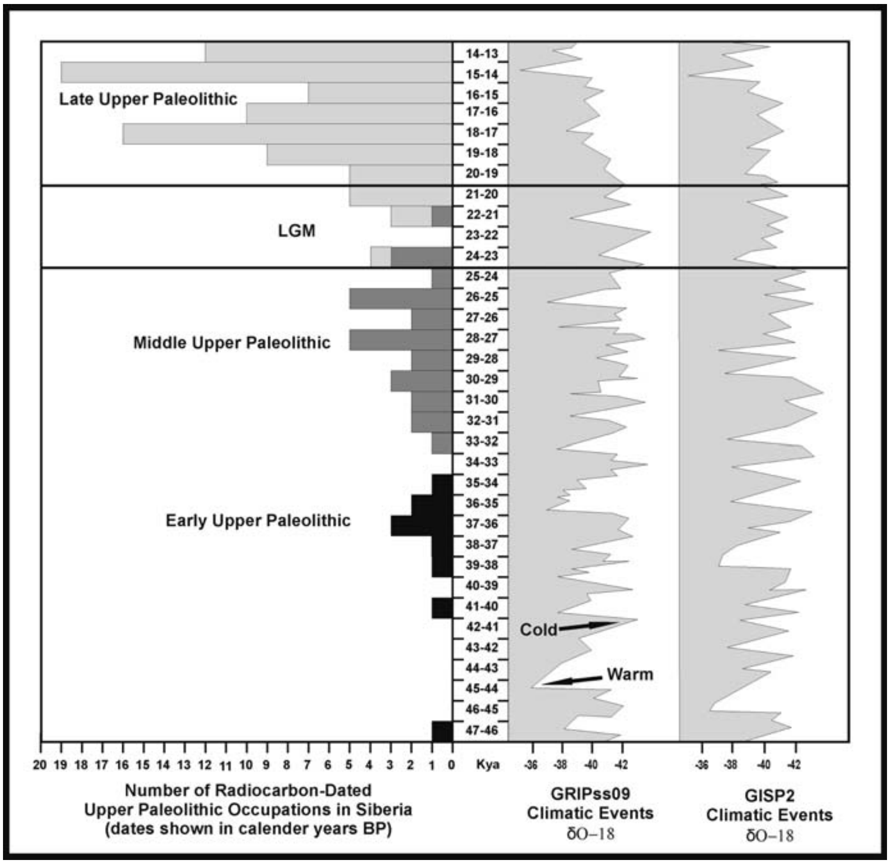

Fig. 4 Number of radiocarbon-dated human occupations across Siberia (data from Goebel, 2004a, b; Vasil'ev et al., 2002) alongside the GRIPss09 and GISP2 oxygen-18 curves showing warm and cold oscillations during the last third of the Upper Pleistocene (data from Johnsen et al., 2001; from Graf, 2005)

of Siberia during the LGM (Barton et al., 2007; Kuzmin and Keates, 2005a, b; Kuzmin and Orlova, 1998; Surovell and Brantingham, 2007; Vasil'ev et al., 2002).

As climate ameliorated following the LGM, LUP sites and associated technologies emerged in southern Siberia and soon after appeared north and east in arctic Siberia and Alaska by 14,000 cal BP (Dolukhanov et al., 2002; Goebel, 1999; Hoffecker and Elias, 2007; Vasil'ev et al., 2002; Yesner, 2001). LUP tool stones are predominantly fine-grained silicates, and primary reduction is typified by bifacial wedge-shaped and *tortsovyi*[4] microblade core technologies as well as blade and flake core technologies (Fig. 3). Microblades are exceedingly standardized, measuring 5–8 mm wide (Abramova, 1971; Anderson, 1970; Markin, 1986). Secondary reduction is characterized by unifacial, burin, and bifacial technologies. Common tool forms are transverse burins, large side scrapers, small end scrapers, gravers, retouched microblades, retouched blades, and retouched flakes. Osseous implements consist of slotted points and knives inset with microblade midsections (Abramova et al., 1991), and beads and pendants are typical nonutilitarian artifacts. Faunal remains include reindeer, red deer, bison, mammoth, roe deer, argali sheep, wolf or dog, hare, fox, and birds (Ermolova, 1978; Vasil'ev, 2003b). Single mammal species often dominate faunal assemblages (Goebel, 1999). Dwellings, when present, are ephemeral, containing a central hearth with few lithic and faunal remains (Vasil'ev, 2003a). Sites typically occur on low terraces near

[4] The closest English approximation of the Russian term "tortsovyi" is "end." Tortsovyi microblade cores are produced on flakes, sometimes cobbles, in which microblades are detached from the ends or margins of the flake or cobble (Abramova, 1979b). In contrast, wedge-shaped microblade cores begin as bifaces.

rivers and lack interassemblage variability (Abramova, 1979a, b; Abramova et al., 1991; Derevianko, 1998; Ermolova, 1978; Petrin, 1986; Vasil'ev 1992).

The MUP to LUP Transition in Siberia: Lingering Issues

Archaeologically, the transition from MUP to LUP in Siberia is most characteristically distinguished by the addition of microblade technologies to the tool-making repertoire. Typically, the transition is viewed as a gradual process with in-place development of microblades directly from Siberian MUP blade technology (Derevianko, 1998; Lisitsyn, 2000). In contrast, Goebel (1999, 2002) has viewed the transition as abrupt, resulting from the sudden appearance of microblades after a hiatus in cultural occupation (Goebel, 1999, 2002). This disagreement seems to center on differing ways researchers explain technological change in prehistory and the problematic dating of several MUP and LUP cultural occupations.

Microblade Emergence and Technological Change

Since early Soviet times and the inclusion of Marxist thought in socio-economic studies, Russian archaeology has been considered a historical science with archaeologists explaining cultural change as the result of in-situ evolution of one cultural phenomenon into another (Davis, 1983; Gellner, 1980). Archaeological technologies have deep-seated origins within previous technologies in an area. Therefore, microblades emerged slowly from in-situ microlithization of blade technology of the MUP (Artem'ev, 2003; Derevianko, 1998; Derevianko et al., 2003; Lisitsyn, 2000; Mochanov, 1977; Vasil'ev, 1996).

Although specific definitions of microblade core reduction techniques are available in the literature (Abramova, 1979b; Anderson, 1970; Artem'ev, 1999; Bleed, 2002; Flenniken, 1987; Kobayashi, 1970; Markin, 1986), many studies ignore these exact definitions and assign exhausted subprismatic cores and associated bladelets as "microcores" and "microblades" (Derevianko et al., 2003; Lisitsyn, 2000, 1987; Vasil'ev, 1996). A direct link is assumed between the increased use of small blades in MUP sites and use of the formal microblade technologies of the LUP. Therefore, MUP bladelet technologies are regularly suggested as the progenitors of wedge-shaped and *tortsovyi* microblade technologies (Akimova et al., 2003; Artem'ev, 2003; Lisitsyn, 2000; Vasil'ev, 1996). If this was the case, then why did LUP flint-knappers continue to produce small blades after microblade technologies were invented? Surely small blade cores and bladelets could have resulted from cores with relatively long use-lives and may have nothing to do with the appearance of microblades. Goebel (1999, 2002) contends that the specialized wedge-shaped and *tortsovyi* microblade cores and associated composite microblade tools of the LUP may actually have roots outside of Siberia.

Timing of Microblade Emergence and LGM Abandonment

The exact timing of microblade emergence is riddled with several problems. Not only are there disagreements about what microblades represent, but problematic dating of sites has further muddied the waters. If the transition from the MUP to LUP entailed gradual emergence and incorporation of microblades into pre-existing Siberian Upper Paleolithic toolkits, then there should be overlap in time between the two techno-complexes. In contrast, if the transition was abrupt and microblade technology was novel to Siberian LUP toolkits, then there should be a chronological gap between MUP and LUP sites.

Goebel (2002) proposed a chronological gap and abrupt transition of the MUP to LUP, pointing mainly to the equivocal nature of dates reportedly spanning the LGM. Goebel (1999, 2002) suggests MUP human populations dwindled to archaeologically invisible levels during the LGM because the Siberian landscape lacked crucial fuel supplies necessary for human survival. Similarly, other treeless Asian biomes may also have been devoid of humans during this harsh climatic event (Davis and Ranov, 1999).

Recent work investigating the latest Pleistocene human colonization of the high Tibetan Plateau and the potential use of yak dung as an alternative fuel source suggests the amount of dung needed to survive may not have been available until human pastoralists domesticated the yak (Brantingham et al., 2007; Madsen et al., 2006; Rhode et al., 2007). Therefore, dung may have been an unreliable fuel source during the LGM since large mammal numbers were low at this time. In Goebel's (1999, 2002) scheme, humans recolonized Siberia after the LGM, when large mammal populations and trees increased and fuel resources were more readily available. This recolonization event is recognized by the post-LGM arrival of the LUP and associated microblade technologies (Goebel, 1999, 2002, 2004b). Various analyses of the radiocarbon (^{14}C) data from Siberia have been found to support his interpretation (Dolukhanov et al., 2002; Graf, 2005; Surovell et al., 2005).

In contrast, Kuzmin and Keates (2005a, b; Vasil'ev et al., 2002) argue that several sites date to the LGM, and abandonment did not occur. Such sites include the MUP cultural layers from Tomsk and Shestakovo (Cultural Layer 17) in the Ob' River region, Tarachikha, Shlenka, and Ui-1 (Cultural Layer 2) in the Enisei River region, Ust' Kova and Mal'ta in the Angara River region and LUP layers from Mogochino-1 and Shikaevka-2 in the Ob', Novoselovo-6 in the Enisei, Krasnyi Iar-1 in the Angara, Studenoe-2 in the Transbaikal region, Mamakan-2 and Tesa in upper Lena River drainage, and Ikhine-2 and Verkhne Troitskaia in Iakutia. Each case is problematic; either the age is based on a single date from a cultural occupation, the geologic context of the date is questionable, or the date is incongruent with other associated ^{14}C determinations from the site. Pettitt et al. (2003) have warned against these various problems, arguing that archaeologists should consider such ^{14}C age determinations unreliable.

Keeping Pettitt et al.'s (2003) concerns in mind, the only compelling LGM-aged ^{14}C date comes from the Mal'ta burial: 19,880 ± 160 (OxA-7129) BP (Richards et al., 2001). Although it does not overlap with other dates from the site (Medvedev et al., 1996), it is a direct age determination on human bone and, as reported, seems to have resulted from a properly pretreated sample (Richards et al., 2001). More dates will confirm the reliability of this age determination, but as it stands, this direct date on human remains suggests MUP peoples may have lingered in the Angara River valley until the very beginning of the LGM at about 24,000 cal BP. Even if this Mal'ta date can be replicated, it does not suggest a direct tie to the LUP sites that seem to post-date the LGM. Clearly, we need to better understand the age and character of the first microblade technologies in Siberia, and studies testing chronological gaps and technological differences need to be undertaken on a site-by-site and region-by-region basis.

The above interpretations have been largely based on the development of chronologies and typologies (Abramova et al., 1991; Akimova et al., 2005; Derevianko, 1998). Recently, a few attempts have focused on reconstructing Upper Paleolithic hunter-gatherer behaviors that generated site assemblages (Goebel, 2002, 2004a; Vasil'ev, 1996), but most of these are limited to literature reviews (Goebel, 1999, 2004b; Vasil'ev, 1992, 1993, 2000). Considerations of MUP and LUP hunter-gatherer ecology and adaptive responses are largely lacking. As a result, the questions addressed above remain unanswered.

In this chapter, I take a first step in addressing the emergence of microblades and abandonment issues by comparing blade and microblade technologies of the MUP and LUP from one region—the Enisei River in south-central Siberia. By doing so, I characterize the nature of the transition in this region to explain how it relates to the colonization of the Siberian mammoth steppe.

Enisei River-Front Property: Sites and Lithic Assemblages

Sites considered here are located along the Enisei River between the city of Krasnoiarsk to the north and the small village of Maina to the south (Fig. 5). For several reasons, this region provides an interesting laboratory for pursuing the MUP to LUP transition. First, the area has witnessed intensive archaeological fieldwork during the past century, providing several Upper

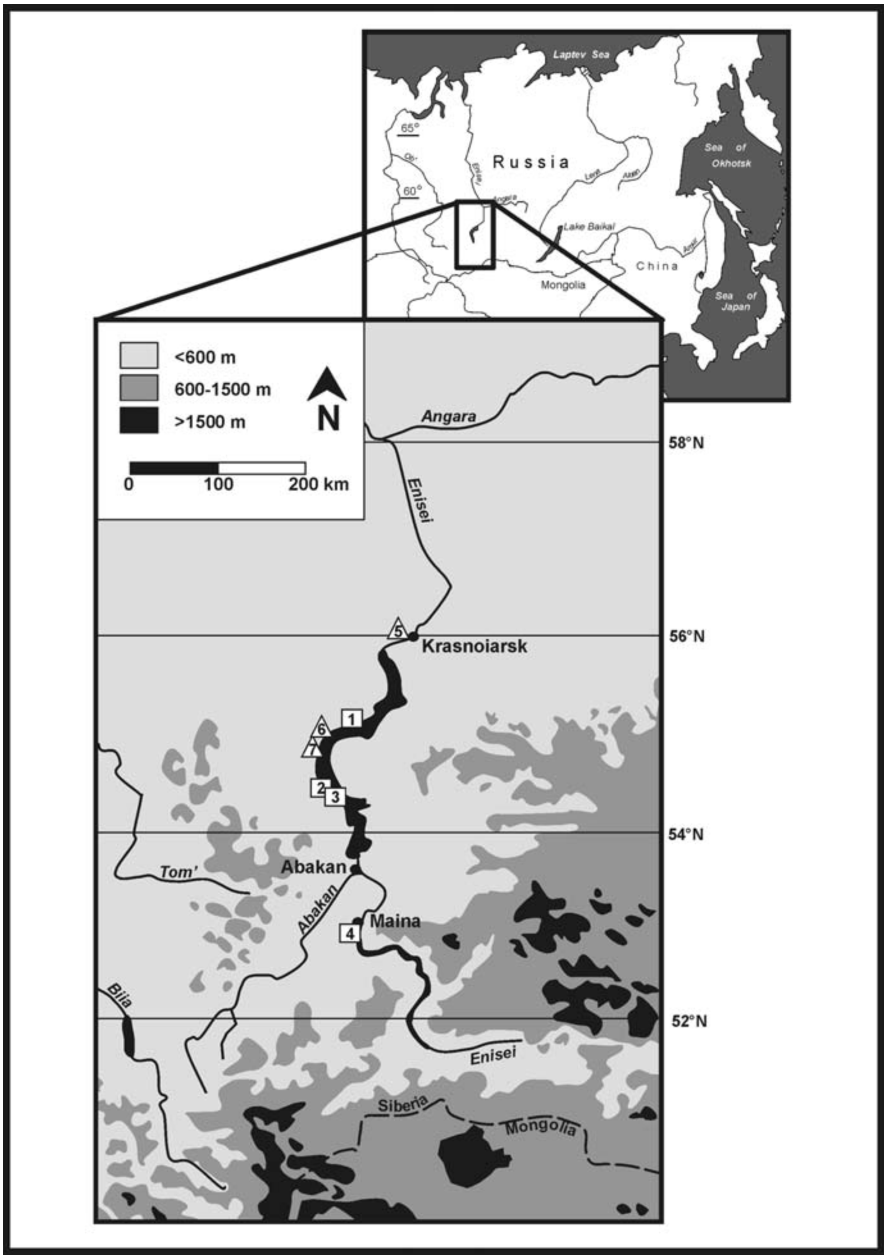

Fig. 5 Site location map. MUP sites: (1) Kurtak-4, Kurtak-5; (2) Afanas'eva Gora; (3) Sabanikha; (4) Ui-1. LUP sites: (5) Afontova Gora-2, Afontova Gora-3; (6) Novoselovo-7; (7) Kokorevo-1, Kokorev-2

Paleolithic sites clustered in a single region. Second, several artifact assemblages are relatively large, and from well-documented and buried contexts. Finally, the Enisei River valley has also been the focus of much paleoecological work, providing a place where paleoenvironments can be reconstructed for large parts of the last glacial cycle (e.g., Frechen et al., 2005; Haesaerts et al., 2005; Nemchinov et al., 1999; Tseitlin, 1979; Zander et al., 2003). Chronological considerations and lithic analysis presented in this chapter come from five MUP and five LUP sites briefly discussed below.

Studied materials came from MUP and LUP cultural layers from sites positioned in loess or fluvial deposits of river terraces along the Enisei River (Table 1). Artifact distributions and features are generally well-documented for these sites, and all

Table 1 Assemblage data for MUP and LUP sites

Site; latitude	Cultural layer	Dates[a,b]	Lithic assemblage samples: Debitage	Cores	Tools	Total	References
MUP							
Sabanikha; 54°35′N	Main	26,950–21,940 ^{14}C BP 31,500–26,500– cal BP	1,218	69	357	1,644	Lisitsyn (2000)
Kurtak-4; 55°10′N	1	26,230–23,070 ^{14}C BP 31,000–27,600 cal BP	1,163	84	44	1,291	Lisitsyn (2000), Svezhentsev et al. (1992) and Drozdov et al. (1990)
Kurtak-5; 55°10′N	Main	26,000–23,000 ^{14}C BP 31,000–27,500 cal BP	4	8	51	63	Lisitsyn (2000)
Ui-1; 52°58′N	2	23,890–16,520 ^{14}C BP 28,800–19,600 cal BP	1,247	75	173	1,495	Vasil'ev (1996) and Vasil'ev et al. (2005)
Afanas'eva Gora; 54°40′ N	Main	≥20,000 ^{14}C BP ≥24,000 cal BP	1,209	51	205	1,465	Lisitsyn (2000)
LUP							
Novoselovo-7; 55°00′N	Main	16,200–13,900 ^{14}C BP 19,500–15,500 cal BP	1,245	84	133	1,462	Abramova (1979b) and Lisitsyn (1996)
Afontova Gora-2; 56°00′N	C_3	21,500–20,300 ^{14}C BP 26,000–24,400 cal BP	15	16	62	93	Tseitlin (1979), Astakhov (1999) and Abramova et al. (1991)
Afontova Gora-3; 56°00′N	2	16,000–13,500 ^{14}C CP 19,000–15,300 cal BP	179	188	420	787	Astakhov (1999)
Kokorevo-1; 54°56′N	2-3	16,400–12,400 ^{14}C BP 19,500–14,300 cal BP	1,190	75	158	1,423	Svezhentsev et al. (1992), Abramova (1979a) and Abramova et al. (1991)
Kokorevo-2; 54°56′N	Main	13,530–11,890 ^{14}C BP 16,300–13,800 cal BP	1,300	112	286	1,698	6,1

[a] Radiocarbon ages are given at 2-σ. These were calibrated using the Calib 5.0.1 (Intcal04 Curve) program (Reimer et al., 2004) for dates ≤21,300 ^{14}C BP and CalPal-Online (Calpal 2005 SFCP Curve) (Danzeglocke et al., 2005) for dates >21,300 ^{14}C BP.
[b] No radiocarbon dates have been reported for Afanas'eva Gora and Afontova Gora-3. Ages for these sites are based on correlation with radiocarbon-dated sites in similar stratigraphic situations.

Table 2 AMS radiocarbon samples and ages

Site	Provenience (cultural layer; excavation square)	Lab number	Material	δ^{13}C	F Value	Age estimate
Sabanikha	CL	AA-68665	Bulk Charcoal (*Picea*/*Larix*)	–22.5	0.0368±0.0011	26,520 ± 250
Sabanikha	CL	AA-68666	Bulk Charcoal (*Picea*/*Larix*)	–24.4	0.0395±0.0012	25,960 ± 240
Sabanikha	CL	AA-68667	Bulk Charcoal (*Picea*/*Larix*)	–24.0	0.0410±0.0013	25,660 ± 250
Kurtak-4	Upper CL; K28-30/L28-29	AA-68668	Hearth Charcoal (*Picea*)	–23.7	0.0315±0.0012	27,770 ± 310
Kurtak-4	Upper CL; K28-30/L28-29	AA-68669	Hearth Charcoal (*Picea*)	–23.6	0.0436±0.0015	25,160 ± 280
Kurtak-4	Upper CL; K28-30/L28-29	AA-68670	Hearth Charcoal (*Picea*)	–24.8	0.1099±0.0016	17,740 ± 120
Novoselovo-7	CL; A5	AA-68674	Bone	–19.3	0.1794±0.0032	13,800 ± 140
Novoselovo-7	CL; A4	AA-68672	Bone	–18.3	0.1868±0.0032	13,480 ± 140
Afontova Gora-2	C3; D2	AA-68663	Dispersed Charcoal (*Salix*/*Calluna*)	–25.4	0.1757±0.0017	13,970 ± 80
Afontova Gora-2	C3; D2	AA-68664	Dispersed Charcoal (*Salix*/*Calluna*)	–25.0	0.1778±0.0018	13,870 ± 80
Afontova Gora-2	C3; D1	AA-68662	Dispersed Charocal (*Salix*/*Populus*)	–24.6	0.2168±0.0021	12,280 ± 80

sites have yielded rich sets of faunal remains. MUP materials came from the sites of Sabanikha, Kurtak-4, Kurtak-5, Ui-1, and Afanas'eva Gora, and reportedly date from about 31,500–19,600 cal BP. LUP materials reportedly span from about 24,400–14,000 cal BP and include assemblages from the sites of Novoselovo-7, Afontova Gora-2, Afontova Gora-3, Kokorevo-1, and Kokorevo-2 (Abramova, 1979a, b; Astakhov, 1999; Lisitsyn, 2000; Vasil'ev, 1996).

The Transition

The spread of modern humans into subarctic and arctic Siberia and the transition from the MUP to LUP are considered by addressing both the timing of these techno-complexes and the technological changes associated with them. Charcoal and bone samples were gathered from curated collections and submitted for AMS ^{14}C dating to aid in developing a firmer understanding of the timing of MUP and LUP industries in the Enisei River region. Lithic assemblages were analyzed to inform on the technological changes from the MUP to LUP and, ultimately, help define the behaviors that produced these techno-complexes, such as the way in which MUP and LUP foragers[5] were provisioning and organizing themselves on the landscape.

Chronology

To assess whether a chronological gap exists between the MUP and LUP, both previously published and new ^{14}C dates obtained from the sites discussed above were evaluated using several criteria to "clean-up" equivocal ^{14}C age estimates. The set of criteria I used are discussed in more detail elsewhere (Graf, 2008), but they are based primarily on Pettitt et al. (2003) with added consideration of specific stratigraphic and paleoecological contexts from each site. Any ^{14}C ages deemed reliable were retained to establish a chronology of occupation. Following evaluation, multiple ^{14}C assays from the same cultural layer were averaged by calculating a pooled mean to determine the age of a cultural occupation. Next, the ^{14}C age ranges for each "occupation" were converted to calendar years using the Calib 5.0.1 (INTCAL04 curve) program for dates $\leq$21,300 ^{14}C BP and CalPal-online (2007 H curve) for dates >21,300 ^{14}C BP (Danzeglocke et al., 2007; Reimer et al., 2004).

A total of 49 ^{14}C age estimates are reported for the sites studied here (Fig. 6). Of these, 11 are new AMS determinations obtained at the NSF-Arizona AMS facility in Tucson, Arizona and recently reported in Graf (2008) (Table 1). Figure 6 shows several noticeably problematic ^{14}C estimates that cannot reliably date the age of these sites, ranging from incredibly large standard deviations to the abundance of outliers. After carefully considering every date, 16 dates were found to be unreliable. For instance, some of these dates did not overlap with others from the same cultural layer at 2-σ and could be discounted based on questionable geological contexts. Other dates had 1-σ errors of >1,000 ^{14}C years, and therefore 2-σ age ranges of >4,000 ^{14}C years, making them meaningless in establishing a chronology. Figure 7 presents the reliable ^{14}C dates remaining after evaluation.

Cultural occupation ages were identified by calculating pooled means of ^{14}C age estimates for each cultural layer that overlapped at 2-σ. Dates that did not overlap at 2-σ, but cannot comfortably be rejected, are shown with a singe bar that encompasses the entire age range possible. Figure 8 presents a new chronological curve in both ^{14}C and calendar years for these cultural occupations. None of these Enisei River sites unequivocally date to the LGM.

Technological Organization

One very productive means of understanding Paleolithic behavior is the study of the organization of lithic technologies and provisioning strategies (Binford, 1979; Kuhn, 1995; Nelson, 1991; Torrence, 1983). In this study, I reconstruct MUP and LUP technological organization and provisioning to explain similarities and differences in land-use organization. Hunter-gathers use their technologies to

[5] In this essay I use the term "forager" as a synonym for hunter-gatherer.

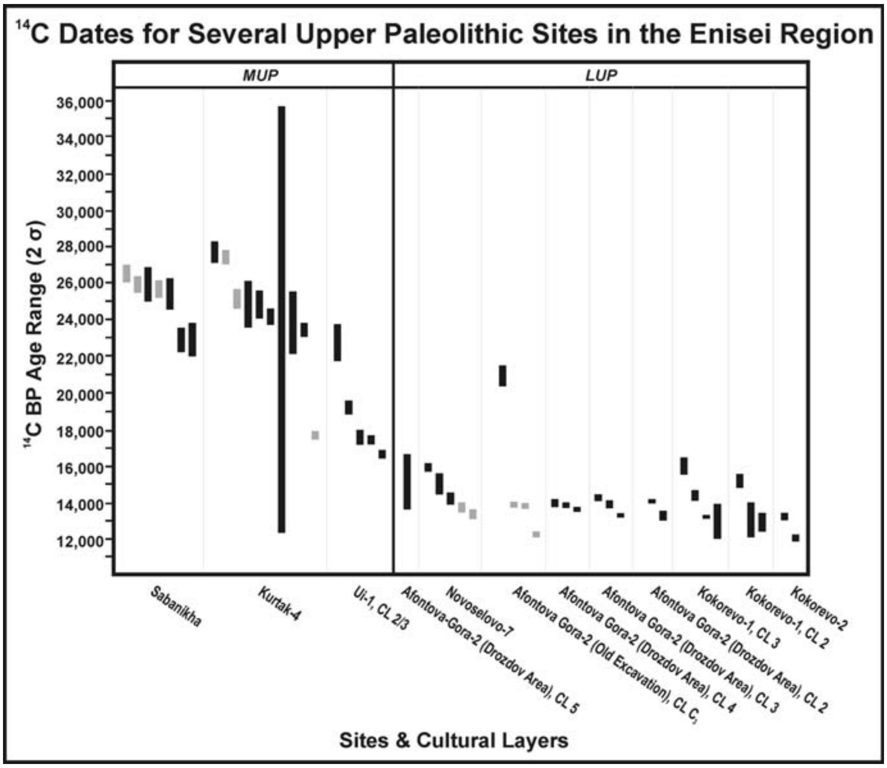

Fig. 6 Radiocarbon chart showing all age ranges at 2-σ (Abramova, 1979a, b; Abramova et al., 1991; Drozdov and Artem'ev, 1997; Lisitsyn, 2000; Tseitlin, 1979; Vasil'ev, 1996; Vasil'ev et al., 2005; this study). *Solid black bars* represent previously reported age ranges, and *gray bars* represent new age ranges obtained during this study

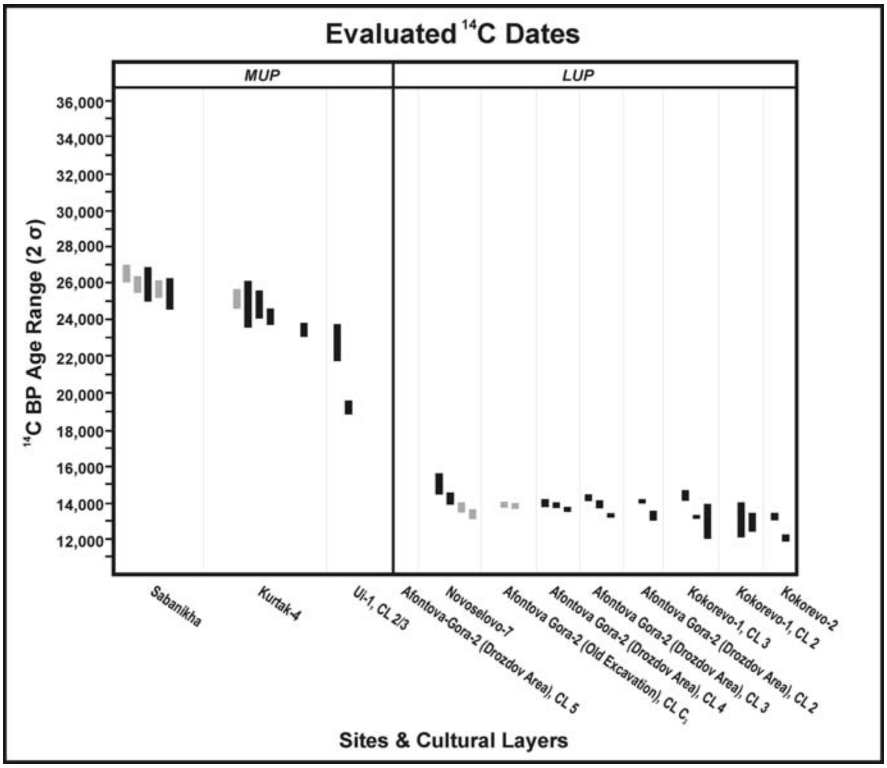

Fig. 7 Radiocarbon chart showing age ranges determined to represent good estimates after evaluation

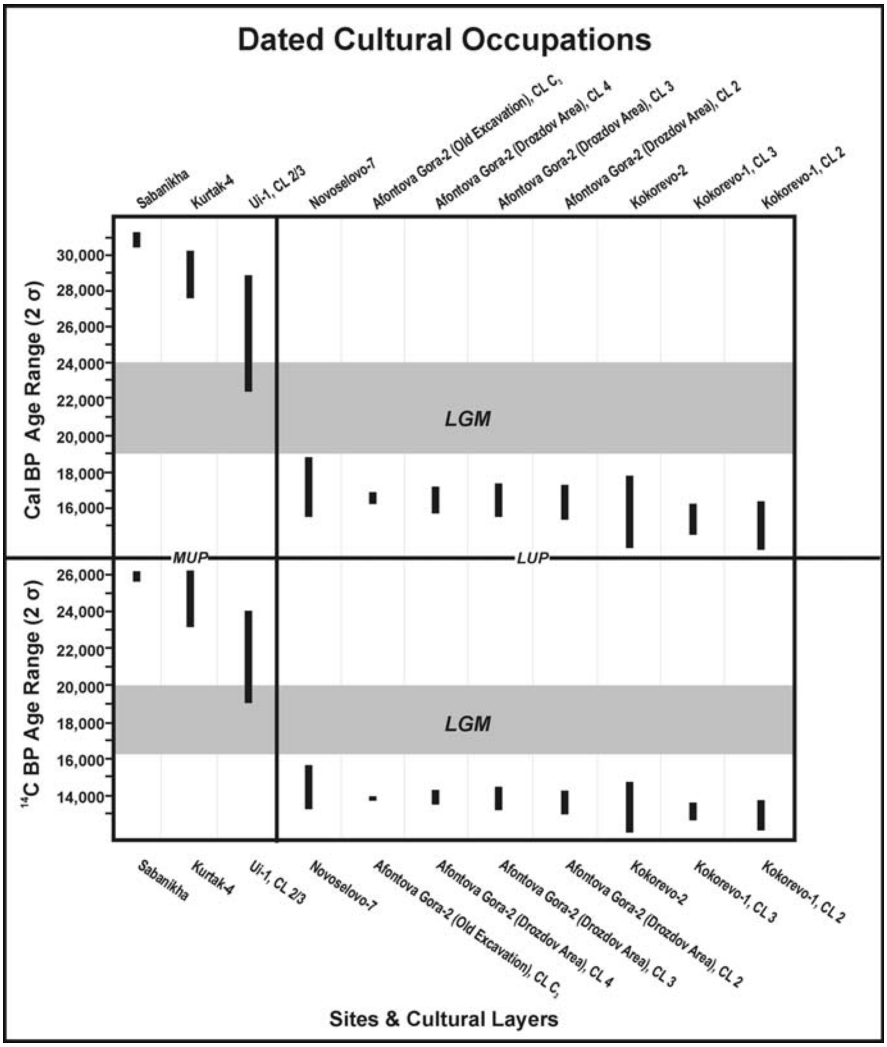

Fig. 8 Chronology for cultural occupations from Enisei River sites included in this study. Radiocarbon years are presented below and calendar years are above

extract food resources from the landscape; therefore, distributions of potential food resources guide hunter-gatherer foraging and land-use (Binford, 1980, 2001; Kelly, 1995). The decision to select alternative land-use strategies will influence foragers' chances in effectively acquiring food resources. The strategies used to exploit both lithic and faunal landscapes and allow hunter-gatherers to be consistently supplied or provisioned with resources are complementary (Binford, 1979). Therefore, the reconstruction of lithic provisioning strategies can inform on hunter-gatherer foraging and land-use (Kuhn, 1995).

With regard to technological provisioning, the hands-on time expended in manufacturing stone tools may not have been as important to hunter-gatherers' schedules as the actual time and energy spent directly procuring lithic raw materials. To some extent, hunter-gatherers have to plan for future exigencies by provisioning themselves with essential raw materials and stone implements needed in food acquisition and processing. Therefore, ensuring that lithic resources are always available, no matter the circumstances, is extremely important. Technological provisioning, as suggested by Kuhn (1995), can come in two basic forms—provisioning individuals and provisioning places.

Highly mobile foraging groups need to plan for future demands by supplying individuals with ready-to-use tools and light-weight cores. When on the move, predicting distance to toolstone sources and maintaining tools are challenges that must be anticipated. In situations where hunter-gatherers provision individuals, an optimal use of artifacts per weight is ideal, especially since carrying costs of heavy artifacts would be too great for mobile foragers (Kelly, 1988; Kuhn, 1995, 1992). Under these circumstances, a provisioning-individuals strategy minimizes the risk of not being prepared for the next hunting and/or processing opportunity, since lithic resource procurement is either unknown or distant.

Archaeologically, the more mobile groups are, the more we would expect to find them provisioning individuals with highly formalized toolkits. Toolstone procurement should be of both local and nonlocal toolstones. Core technologies should be formalized, prepared, and capable of withstanding long use-lives. Cores should have been highly standardized to ensure the tool-maker could always predict the outcome of production and maintenance. Further, cores should be lightweight for long-distance transport. Tool production should be geared toward the manufacture of formal implements because these can be made in advance of use and intensively curated or economized. Mobile foragers need to maintain a ready supply of tools or raw material at all times (Kelly, 1988, 1995, 1996, 2001; Kuhn, 1995; Odell, 1996; Parry and Kelly, 1987).

A hunter-gatherer group that consistently resides in one place or repeatedly revisits that place does not necessarily need to plan for future lithic resource shortfalls. This kind of hunter-gatherer can afford to provision each place of occupation (e.g., residential base, extraction location) with lithic raw material because future needs can be more effectively predicted. Such hunter-gatherers are more familiar with local resources, they can provision places with necessary toolstones by storing lithic resources acquired via logistical forays or by positioning site locations at high-quality raw material resource locations. Therefore, the strategy of provisioning places typifies less mobile hunter-gatherers (Kuhn, 1992, 1993, 1995).

Several aspects of the lithic artifact record can be expected from hunter-gatherers who were provisioning places. Toolstone procurement should be predominantly local with some relatively nonlocal resources obtained while foragers are out on logistical forays. Core technologies should be informal and unstandardized. Further, since transport of cores is highly unlikely, cores should be relatively heavy, since there would be no need for light-weight core technologies. Tool production should be geared toward manufacture of informal implements because there is no need to make tools in advance of use. Tool use-life should be relatively short with tools discarded while theoretically still usable (Kelly, 1988, 1995, 2001; Kuhn, 1995; Odell, 1996; Parry and Kelly, 1987).

This paper presents preliminary data on toolstone procurement and primary and secondary reduction technologies in an effort to reconstruct Siberian Upper Paleolithic technological organization and provisioning strategies. Lithic variables include (1) frequency of raw material, (2) frequency of secondary or alluvial cobble cortex, (3) frequency of informal cores, (4) frequency of primary reduction technology types, (5) comparison of blade and microblade widths, (6) frequency of tool production types, and (7) frequency of formal tools.

Toolstone Procurement

The lithic landscape of most of Siberia is not well-known, and unfortunately this is also case for the Enisei River region. Few geological surveys have been conducted, and the surface geology is nearly unknown via publication (but see Malkovets et al., 2003). Fine-grained lithic raw materials, especially cryptocrystalline silicates (CCS) and quartzites (Qzite), are readily available in river cobble form along the Enisei and its many tributaries (Elena Akimova, 2004, personal communication). Undoubtedly, we are limited in what we can say about the distances that toolstones traveled after being procured. Nevertheless, some information regarding their procurement can be gleaned from the data by investigating variables such as frequencies of raw materials and cortex types present in the assemblages.

A comparison of raw material frequencies from both sets of assemblages (Fig. 9) indicates that MUP and LUP flint-knappers were regularly procuring and utilizing relatively high-quality

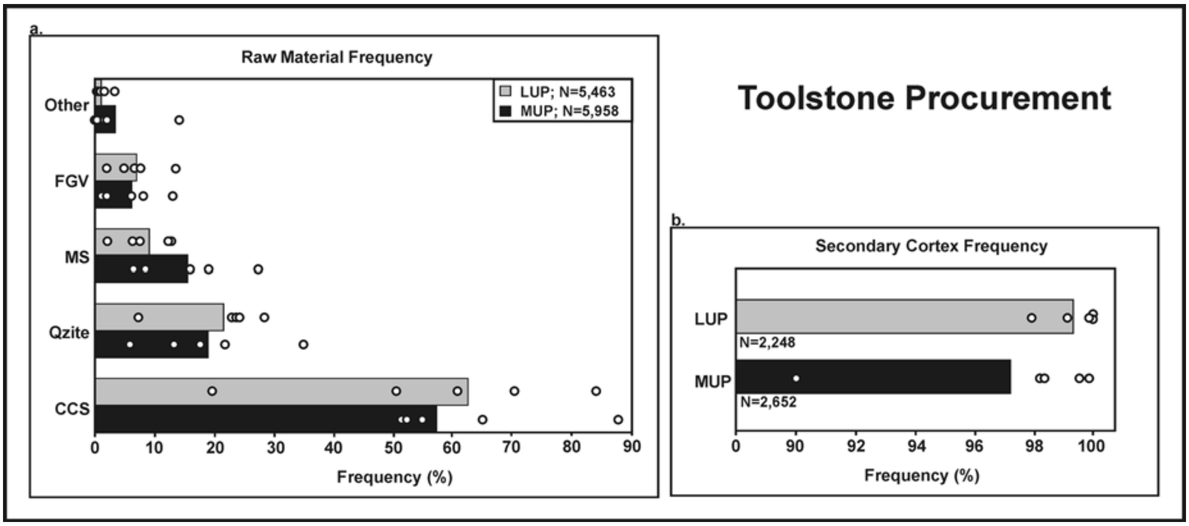

Fig. 9 A comparison of MUP and LUP toolstone procurement: **a**) mean raw-material frequencies, **b**) mean secondary-cortex frequencies. *Circles* represent individual assemblage frequencies

toolstones such as CCS, quartzite, meta-siltstone (MS), and fine-grained volcanic (FGV) materials in similar frequencies. Other lower quality toolstones (e.g., quartz, granite, diorite, sandstone) were procured much less frequently. Likewise, both techno-complexes do not vary in the frequencies of secondary cortex on artifacts. Overwhelmingly, secondary cortex is present on these artifacts, suggesting many local toolstones were being procured and consumed at all of the sites. These data indicate that both MUP and LUP sites served as retooling locations for high-quality toolstones.

Primary Reduction

Comparing MUP and LUP primary reduction, there are several differences (Fig. 10). The obvious difference between the two techno-complexes is the lack of microblade reduction technologies in the MUP. Microblade reduction technologies employed during the LUP include the manufacture of highly formalized, bifacial, wedge-shaped cores, as well as *tortsovyi* microblade cores.

Examination of the number of formal versus informal cores indicates LUP formal core production was much higher—nearly 40%, compared with about 22% for the MUP. Formal cores are those prepared before use and include blade, bladelet, and microblade cores; whereas informal cores are unprepared assayed cobbles, flake cores, and bipolar cores.[6] Individual assemblage frequencies show that LUP assemblages have much less variation in the frequency of formal core production than the MUP, possibly suggesting more standardization in core production than in the MUP.

To further consider blade versus microblade standardization, blade and microblade width measurements are compared (Fig. 11). Variability within MUP blades and LUP blades and between MUP and LUP blades is considerably high, while variability within microblades is extremely low. Therefore, LUP microblade standardization is significantly higher than either MUP or LUP blade standardization. Another interesting pattern is that most blades in the later MUP assemblages (Ui-1 and Afanas'eva Gora) are smaller than those in the more ancient Sabanikha assemblage, though large blades were still being produced at these later sites. These data indicate that blade cores were more intensively reduced, possibly to near-exhaustion at the sites of Ui-1 and Afanas'eva Gora.

Overall, primary reduction during the LUP was more formalized, standardized, and economized

[6] Bipolar cores were produced by percussor on anvil technique.

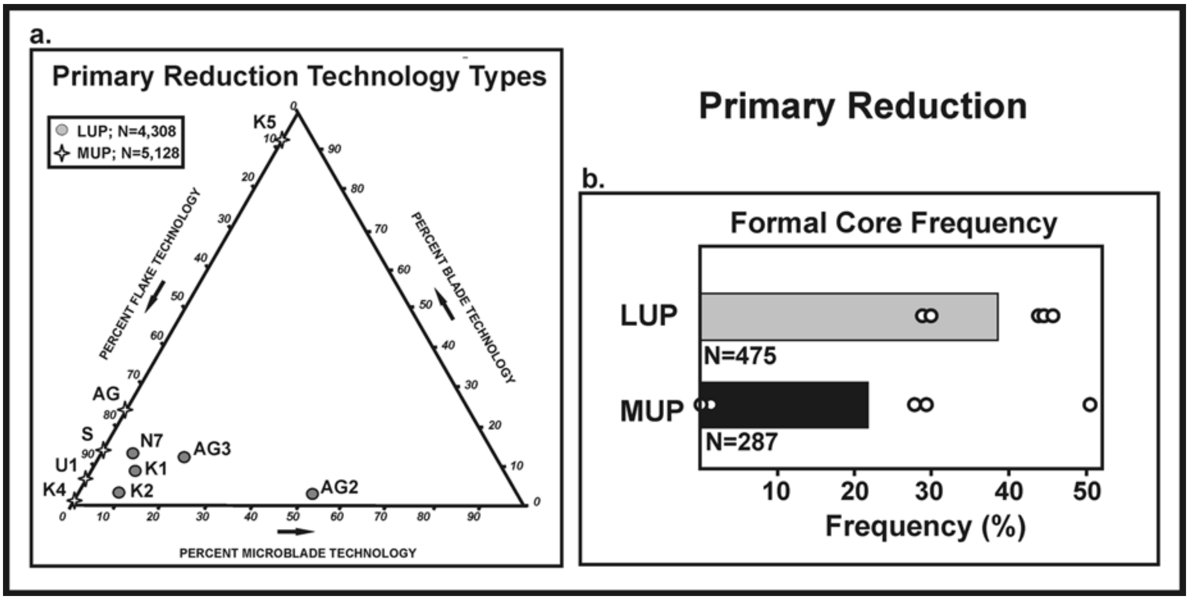

Fig. 10 A comparison of MUP and LUP primary reduction: **a**) relative frequencies of flake, blade, and microblade technologies by assemblage; **b**) mean formal core frequencies. *Circles* indicate individual assemblage frequencies

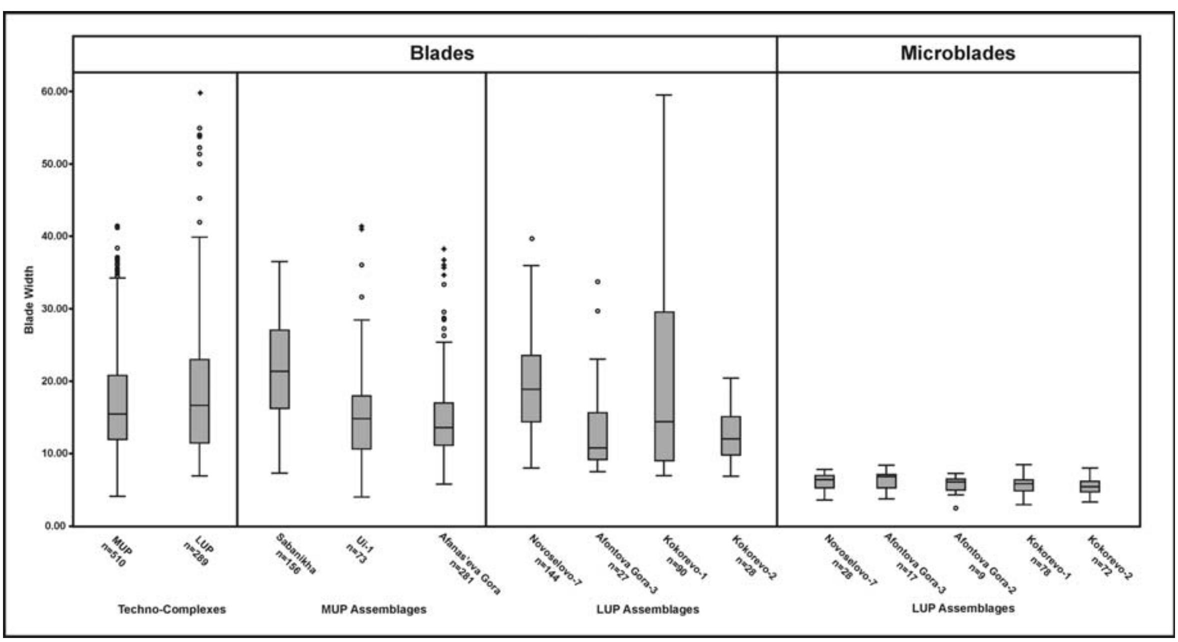

Fig. 11 MUP and LUP blade (width) standardization. Comparisons between the techno-complexes are made for macroblades only, and comparisons within the techno-complexes are made for MUP macroblades, LUP macroblades, and LUP microblades. *Boxplots* show medians, lower quartiles, upper quartiles, and outliers for each sample's width

than in the MUP. The use of highly formalized microblade cores was a time-intensive proposition that took several steps in preparation and maintenance compared with other core types. Nevertheless, their products—microblades—added a whole new dimension to the already existing primary reduction techniques previously available to Upper Paleolithic hunter-gatherers, by maximizing the number of cutting edges from small transportable microblade cores.

Secondary Reduction

An initial look at the manufacture of tools indicates there are clear differences between MUP and LUP assemblages. Considering the three major tool production types—unifacial, bifacial, and burin (Fig. 12)—more bifaces and burins were produced during the LUP than the MUP, while more unifaces were produced during the MUP. Bifaces are more formal tool types than most unifaces, lending themselves to maintainability and portability (Kelly, 1988). Burins were likely used in slotting osseous points that were then inserted with microblade midsections (Guthrie, 1983a, b), explaining their primary place as a component of this formalized LUP tool industry. A consideration of formal versus informal tool frequencies shows that more formal tools were produced in LUP (64%) than MUP (43%) assemblages. Formal tools include bifaces, side scrapers, end scrapers, combination tools, multiple spurred gravers, and burins. Informal tools include retouched flakes, retouched blades, single-spurred gravers, notches, denticulates, and unifacial knives. Individual assemblage frequencies are more varied for the MUP than LUP, indicating that during the LUP more formal tools were consistently produced compared to the MUP. Therefore, MUP tool production was relatively informal and expedient. In contrast, LUP tool production was formal, and highly curatable tools such as bifaces, burins, and combination tools were produced more regularly.

Discussion

The goal of this chapter is to characterize the nature of the MUP to LUP transition in Siberia and to understand the spread of modern humans into the North. Several sites from the Enisei River in south-central Siberia were studied to address this goal. Previous work in the Enisei region has provided several well-

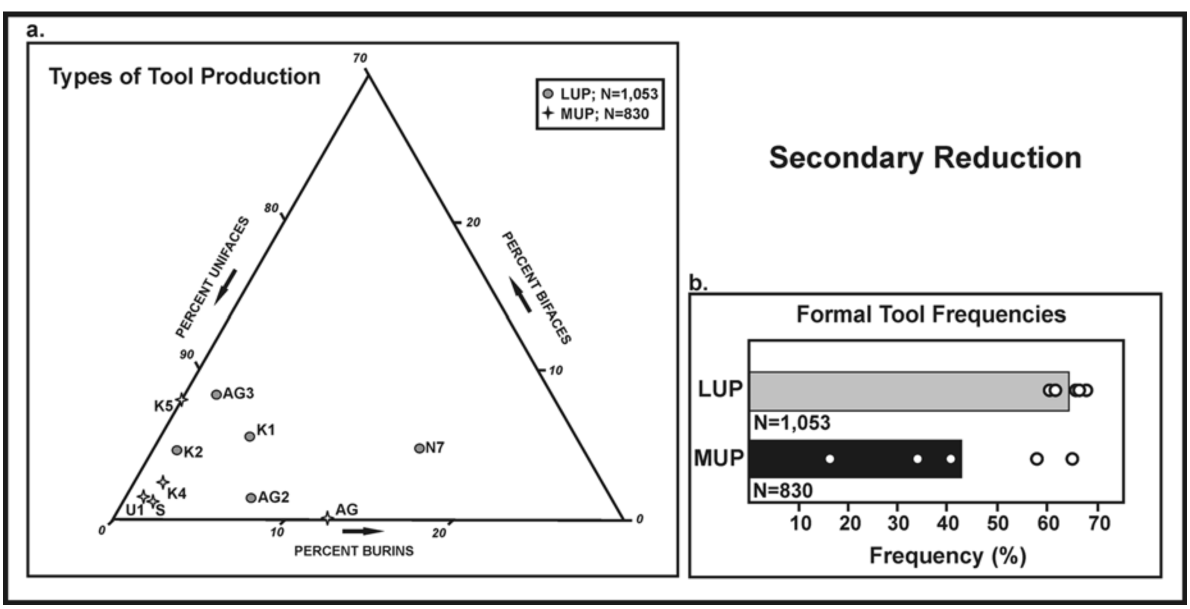

Fig. 12 A comparison of MUP and LUP secondary reduction: **a**) relative frequencies of unifaces, burins, and bifaces by assemblage; **b**) mean formal tool frequencies. *Circles* indicate individual assemblage frequencies

documented Upper Paleolithic site assemblages, making this region an excellent place to begin investigating modern human dispersals in Siberia.

Evaluation of the ^{14}C dates from Enisei River sites studied in this chapter indicates that none of these cultural occupations unequivocally date to the 4,000 year period between about 24,800 and 20,700 cal BP. These preliminary data also point to a possible chronological break in the region's archaeological record between the MUP and LUP; therefore, supporting a decline in human populations during the maximum of the last glacial cycle.

The lithic technological data indicate an abrupt behavioral transition between the two techno-complexes as well, with the lithic expectations for provisioning place generally met by the MUP, and those for provisioning individuals met by the LUP. Toolstone procurement was very similar between the MUP and LUP, with the majority of lithic raw materials locally procured by the makers of both techno-complexes. Three important conclusions can be drawn from these similarities. First, local raw materials, found in the form of river cobbles and readily available at numerous sites along the Enisei River, were selected by both MUP and LUP hunter-gatherers. Second, raw material scarcity was not a concern for either MUP or LUP flint-knappers, and therefore it did not affect their technological decisions. Finally, site locations were likely selected for their toolstone richness and thus became retooling locations during the MUP and LUP, regardless of the provisioning strategies employed.

Hunter-gatherers' provisioning place should not care to conserve lithic raw materials by preparing formal core technology, especially when high-quality raw materials are plentiful. When staying at the same place for long periods, or repeatedly visiting such locations, there is no need to standardize core technologies. In such cases, primary reduction will be expedient and informal. MUP hunter-gatherers of the Enisei region were consistently producing large amounts of expedient, informal primary reduction technologies, and many artifacts were discarded in still-usable condition. Also, the blade and bladelet cores that were produced were highly variable and not significantly standardized. In contrast, LUP foragers had added standardized, formal microblade production to their range of primary reduction techniques. Small, lightweight microblade cores could have produced many linear cm of cutting edge (Guthrie, 1983a) so that the microblades from a single core provided mobile LUP hunter-gatherers with more cutting-edge per unit weight than any other primary reduction technique, including the oft-touted maximum cutting-edge producer, the biface (Flenniken, 1987; Guthrie, 1983a, b; Parry and Kelly, 1987; Kelly, 1988). Likely, when LUP flint-knappers utilized less-formalized core reduction technologies, they selected these detached pieces for use as either microblade cores blanks or tool blanks. These data suggest LUP hunter-gatherers were maximizing usable pieces within their toolkits and provisioning individuals.

When hunter-gatherer provisioning is place-oriented, secondary reduction strategies should be informal and expedient, since there is no need to make implements ready for transport between sites. Tool production should focus on casual selection of ready-to-use tool blanks with minimum preparation of the business end or edge so that the majority of tools produced were informal such as lightly retouched blades and flakes. MUP hunter-gatherers produced higher quantities of informal than formal tools, indicating no need for tool economization. In contrast, tool production in LUP assemblages was formalized. There are more formal than informal tools, and microblade tool technology was employed. Thus, tools were manufactured in anticipation of future use and were capable of being repeatedly resharpened and economized. LUP hunter-gatherers were likely provisioning individuals.

The formalization and standardization of both primary and secondary reduction strategies indicate LUP hunter-gatherers were mobile foragers who provisioned individuals within the group. In contrast, the informal, nonstandardized, and expedient nature of primary and secondary reduction strategies of the MUP indicates these hunter-gatherers were provisioning place and less mobile. Since high-quality raw materials were readily available in the form of river cobbles found at both MUP and LUP sites, I must interpret these basic technological differences between the two techno-complexes as resulting from different human organizational strategies and not from the economization of scarce raw materials by the LUP.

The technological patterns of MUP and LUP assemblages were recognized throughout the MUP and LUP, respectively. Therefore, there seems to be more variation in technological activities, organization, and provisioning strategies between the two techno-complexes than within each. I argue that these changes were significant, indicating an abrupt transition between the MUP and LUP.

Conclusion

During the Upper Paleolithic in south-central Siberia, there was an abrupt transition, not just in technologies employed by hunter-gatherers, but in the organization of the people and the ways in which they were utilizing the landscape. Numerous settlements found between 51°N and 56°N across Siberia, dating from about 32,000 to 24,000 cal BP are evidenced by the presence of the MUP. From what we know about these people, they seem to have been utilizing local resources and various ecological zones and landscapes and maintaining low levels of mobility by provisioning place.

At about 24,000 cal BP, populations in south-central Siberia dwindled to archaeologically unrecognizable levels. Whether or not humans completely disappeared from Siberia during the LGM is not known; however, in the Enisei River basin populations seemed to have been quite low. Possibly during this time Upper Paleolithic Asians pushed into more temperate regions or refugia, where there may have been continuous occupation spanning the LGM (Izuho and Takahashi, 2005; Nakazawa et al., 2005).

With the end of the LGM, LUP foragers re-entered Siberia, bringing a different land-use strategy from that used during the MUP—one in which people were provisioning individuals and were highly mobile, likely moving their residences more frequently than before. Technology had altered to support these changes. Core and tool technologies became more formal and standardized. Highly flexible composite osseous and stone projectile points and knives were manufactured at this time. These implements would have been beneficial in hunting large-range herd animals, such as reindeer, that tended to occur in high frequencies in the LUP faunal assemblages.

The earliest reliably dated microblade technologies in northern Asia come from sites in Hokkaido, Japan dating to 22,000–20,000 ^{14}C (26,500–24,000 cal) BP (Izuho and Takahashi, 2005; Nakazawa et al., 2005; but see Chen, 1984; Chen and Wang, 1989; Lu, 1998 for earlier, but equivocal dates from the Xiachuan microblade site in northern China). While the earliest unequivocally dated microblade sites in Siberia appeared simultaneously in the Transbaikal of southeastern Siberia, and along the upper Enisei River in far south-central Siberia at about 18,000–17,500 ^{14}C (21,000 cal) BP (Astakhov, 1986; Goebel et al., 2000; Graf, 2008). Interestingly, along the Selemdzha River (a tributary to the Amur' River in the Russian Far East), the microblade site of Ust' Ulma-1 has one ^{14}C date of 19,360 ± 65 (SOAN-2619) (~23,000 cal BP) (Derevianko and Zenin, 1995). If this age can be corroborated, it would certainly provide good evidence for the spread of microblade technologies into southeastern Siberia from Japan via the Russian Far East. Perhaps the land-use strategies employed by Siberian LUP foragers and the development of microblade technology first arose in Japan from an LGM, productive mammoth steppe biome in a coastal refugium. Increased mobility may have allowed these foragers to rapidly spread into southern Siberia soon after the LGM.

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