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AMS DATING MAMMOTH BONES: COMPARISON WITH CONVENTIONAL DATING

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ABSTRACT. Fossilized Siberian mammoth remains are important indicators of environmental change in the Late Pleistocene. The NSF-Arizona AMS Laboratory radiocarbon results on amino acid separations compare well with mammoth bone collagen from the same specimens treated by HCl and dated by beta counting (the Russian Academy Geological Institute Radiocarbon Laboratory). Neither laboratory was aware of the other's dates for these comparisons. The results coincide very closely (a difference of 50–800 yr), and demonstrate that AMS dating provides a very good perspective for applications of past mammoth population studies.

INTRODUCTION

The Late Pleistocene (40–10 ka BP) syncryogenic deposits (i.e. accumulated simultaneously with freezing) of Siberia and the Arctic coastal plain of North America contain thick syngenetic ice wedges and well-preserved extinct mammoth remains. These include bones, partially articulated skeletons, and some whole carcasses. Mammoth extinction can only be understood in the context of their temporal and spatial distribution, as well as their diet and the temporal and spatial distribution of available food. Thus, answers to questions surrounding the cause or causes of mammoth faunal extinction require knowledge of a cluster of intricately interrelated palaeogeographical and palaeobotanical conditions. The historically earliest mammoth findings (Pfizenmayer 1926) were by Ides (Yenisey River, 1707), Sarychev (Alazeya River, 1787), and Adams (Lena River, 1799). More than 40 whole carcasses and skeletons have been discovered (Sokolov 1982; Shilo et al. 1983). During the last decade, convincing answers to some of these questions have emerged. Radiocarbon dates of mammoth remains (Vasil'chuk 1992; Vasil'chuk et al. 1997) and a stable isotope study of the permafrost hosting them (Vasil'chuk 1992) are among the data contributing to a systematic history of Late Pleistocene mammoth distribution in vast areas of Siberia and some regions of Europe.

Dating Mammoth Bones

We have summarized about 300 ^{14}C dates of mammoth remains in Siberian permafrost areas (Vasil'chuk 1992; Sulerzhitsky 1995; Vasil'chuk et al. 1997), and about 200 dates from regions of Europe that were permafrost during the Late Pleistocene but not at present (Vasil'chuk 1992; Sulerzhitsky 1995; Stuart 1991). It is known that mammoths inhabited the entire permafrost area from the Arctic coast southward to at least 40°N. Mammoth carcasses have been studied intensely in the regions of present-day permafrost (Sokolov 1982; Shilo et al. 1983). Even in cases of discovery in permafrost, there is no guarantee that the remains had been frozen continuously since death. As redeposition of bones into younger sediments must be considered a possibility, special cleaning procedures are required before ^{14}C dating. The currently acceptable pretreatment technique for beta-counting laboratories, separation of bone collagen with HCl, results in coincident ^{14}C ages on bone specimens from the same skeleton but with different degrees of preservation (Sulerzhitsky 1997; Vasil'chuk and Vasil'chuk 1998). Interlaboratory comparisons employing this pretreatment also show comparable results (Arslanov and Svezhentsev 1993; Long et al. 1994; Vasil'chuk and Vasil'chuk 1998). Accelerator mass spectrometric (AMS) ^{14}C laboratories results on amino acid separations compare well with bone collagen from the same specimens treated by HCl and dated by

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beta counting (Table 1). The NSF-Arizona AMS Laboratory ^{14}C results on amino acid separations compare well with mammoth bone collagen from the same specimens treated by HCl and dated by beta counting (the Russian Academy Geological Institute Radiocarbon Laboratory). Neither laboratory was aware of the other's dates for these four comparisons.

Table 1 AMS and conventional ^{14}C measurements of mammoth remains

Sample locations and coordinates (numbers as shown in Figure 1)	Material	Lab code	AMS date, yr BP (conventional date)	$\delta^{13}C_{PDB}$ (‰)
Middle part of Shchuch'ya River, near Edem'yaha mouth (South Yamal Peninsula, Western Siberia) 67°N, 69°E (1)	Bone	AA-27371	32,090 ± 480	−21.9
Middle part of Shchuch'ya River, near Edem'yaha mouth (South Yamal Peninsula), 67°N, 69°E (2)	Molar	AA-27372	12,535 ± 80	−21.5
Lower Yana River, northwest Yakutia, Mus-Khaya cross-section, 71°N, 136°E (3)	Bone	AA-27373 GIN-8711	35,400 ± 2,000 (34,600 ± 470)	−20.1
Mal'ta River, Angara River Basin, 43°N, 104°E (4)	Bone	AA-27374 GIN-8476	14,940 ± 170 (14720 ± 130)	−21.7
Kostyonki Paleolithic camp, 40 km from Voronezh city, 43°N, 33°E (5)	Bone	AA-27375 GIN-7992	23,120 ± 460 (23,800 ± 150)	−21.3
Shokal'sky Island, Arctic Ocean, 73°N, 74°E (6)	Bone	AA-27376 GIN-8427	13,600 ± 160 (13650 ± 170)	−22.5
Lower Yuribey River (East Yamal Peninsula), 69°N, 69°E (7)	Tusk	AA-27377	10,460 ± 120	−25.0
Sabettayaha River, 30 km from Sabetto Settlement (Yamal Peninsula), 69°N, 69°E (8)	Tusk (very large)	AA-27378	10,420 ± 130	−25.0
Middle Yuribey River (Central Yamal Peninsula), 69°N, 69°E (9)	Tusk	AA-27379	13,940 ± 170	−25.0
Sohontosyo Creek, West Yamal Peninsula, 25 km northeastern Ust'-Yuribey Settlement, 69°N, 69°E (10)	Jaw of baby mammoth	AA-27380	29,700 ± 1,000	−25.0
Sohontosyo Lake, West Yamal Peninsula, 25 km northern Ust'-Yuribey settlement, 69°N, 69°E (11)	Tooth of bison	AA-27381	32,600 ± 1,400	−25.0

DISCUSSION AND CONCLUSION

The mammoth bone dates presented here fill a gap between 32,000 and 10,000 BP in the Yamal Peninsula and provide evidence that mammoths lived in the north of western Siberia between 32 and 10 ka. Until now, their existence in this area during Late Pleistocene was problematic. Combined with other dates from the Siberia permafrost zone, these dates show the continuous existence of mammoths in subarctic regions.

The southern limits of mammoths' aerial extent coincide with the southern limits of polygonal wedge structures (Figure 1). The latter are reconstructed on casts distribution (Vasil'chuk 1992). ^{14}C dates on mammoths show that they lived in permafrost areas. Their population densities are difficult to evaluate on available data, but the dates show no significant gaps in their presence in either Europe or Siberia, except, of course, at times and places where extensive ice sheets existed.

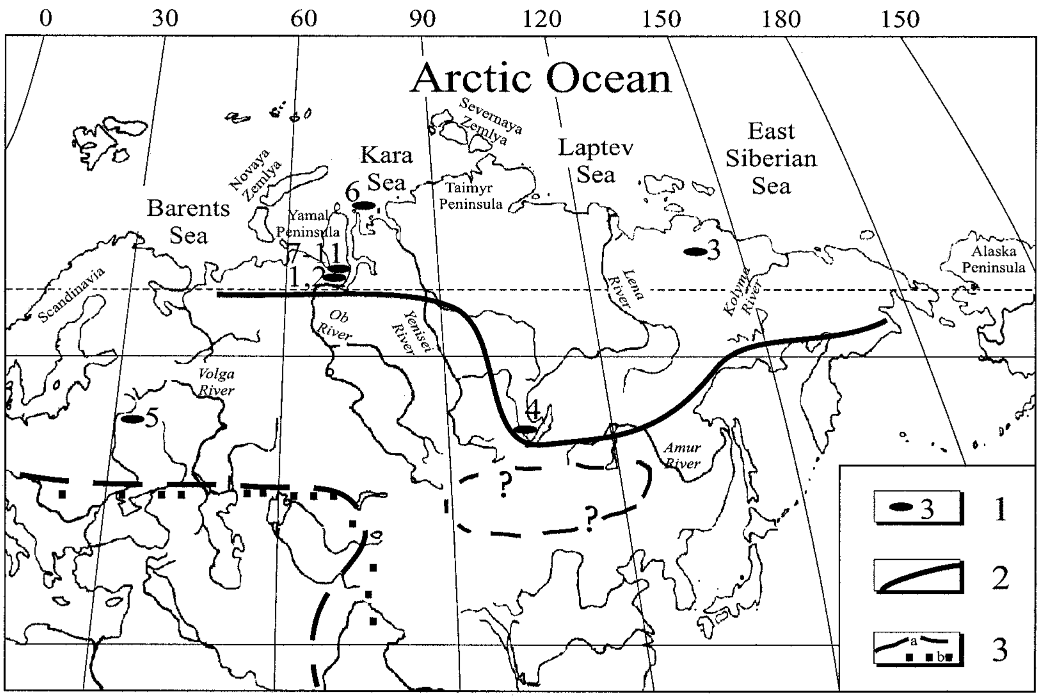

Figure 1 Map of northern Russia showing the location of the AMS-dated mammoth remains and ^{14}C dated oxygen-isotope curves of the Late Pleistocene syngenetic ice–wedge complexes. Key: (1) localities of AMS-dated mammoth remains (the numbers correspond to those in the first column of Table 1); (2) the southern boundary of modern and relict syngenetic ice wedges; (3) the southern boundary of Late Pleistocene palaeopermafrost (in northern China the boundary is problematic) zone (a – after Vasil'chuk 1992) and mammoths' area (b – after Sulerzhitsky 1995).

The fact that mammoth populations fed on grass required their biocoenoses to produce large masses of vegetation in the summer. In winter, mammoths probably consumed grass preserved under the snow cover. If mammoths had greater difficulty breaking the ice (refrozen melted snow), fewer of them would have been able to forage sufficient quantities of grass. Stable oxygen isotope records from ice-wedge ice demonstrate a dramatic shift in winter temperatures (Vasil'chuk and Vasil'chuk 1995, 1997, 1998). Changes in winter conditions, as evidently occurred at the Pleistocene-Holocene transition, was a possible cause both of temperature and food stress for mammoth populations. Similar to present tundra habitants, the mammoths faced a problem attaining food in winter. Even small diminution of available food, as a result of frequent thawing and snow crust formation, could decrease the herd population, and for population responses such as dwarfing (Lister 1993)—when the height of mammoth was not more than 1.5 m (usually the mammoth height was 3–4 m). Warmer temperatures may also have induced greater stress from human predators.

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