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New dates from Ushki-1, Kamchatka, confirm 13,000 cal BP age for earliest Paleolithic occupation

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ABSTRACT

For many years cultural layer 7 at the Ushki sites, Kamchatka was considered to represent the earliest human occupation of Beringia, because four radiocarbon dates indicated an age of 16,000–17,000 calendar years ago (cal BP). In 2003, however, Goebel et al. reported that layer 7 more likely formed only 13,000 cal BP, nearly 4000 years later than N.N. Dikov, the site's primary excavator, originally reported. Some researchers have downplayed the significance of the new dates, continuing to regard Dikov's early dates as evidence that at least some of the hearth and dwelling features previously excavated at Ushki-1 date to as early as 17,000 cal BP. Here we present four new radiocarbon dates (and two previously unpublished dates) on curated charcoal from hearth features excavated at Ushki-1 more than 20 years ago. They indicate that these hearths and associated dwelling features date to about 13,000 cal BP. We now know 15 radiocarbon dates on charcoal from a variety of features and profiles across Ushki-1 and Ushki-5 that indicate the age of layer 7 is about 13,000 cal BP. We discount the four 16,000–17,000 cal BP dates, first, because two of them came from a deeply dug human burial pit and were likely secondarily introduced into the burial; second, because provenience data for the other two dated samples were never reported and do not exist in the records of the radiocarbon laboratories that produced them; and, third, because sediments immediately underlying layer 7 at Ushki-1 are only a few centuries earlier than 13,000 cal BP, providing an important lower-limiting age for the layer-7 occupation. We conclude that the age of all of the layer-7 features at Ushki-1 and Ushki-5 should be considered to be about 13,000 cal BP, at least until the earlier obtained old dates of 16,000–17,000 cal BP can be replicated.

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1. Introduction

When did humans disperse to Beringia? When and how did the first Beringians settle into the maritime regions of the north Pacific basin? These questions are of obvious importance to anthropologists investigating the peopling of the Americas, since most agree that Beringia was a late-Pleistocene "port of call" for humans entering the New World (Dillehay et al., 2008; Goebel et al., 2008). New genetic models predict that late-glacial human populations existed in isolation in Beringia several thousand years before their eventual dispersal to the Americas (Fagundes et al., 2008a; Mulligan et al., 2008; Perego et al., 2009; Schroeder et al., 2009; Tamm et al., 2007), and that the primary route taken followed the northwest North American coast (Fagundes et al., 2008b; Wang et al., 2007), not a new idea but one that has recently gained support among many archaeologists (e.g., Dixon, 2001; Erlandson, 2002; Erlandson et al., 2008; Goebel et al., 2008). However, even though archaeological sites predating 13,000 cal BP[1] have been found in California and the Japanese archipelago, north of these regions along the Pacific coast archaeologists have yet to discover empirical evidence of a late-glacial coastal migration predating Clovis (the earliest well-defined and widespread complex of archaeological sites in North America).

The only late-Pleistocene archaeological site in a near-maritime setting along the south coast of Beringia is Ushki, Kamchatka. Ushki is actually made up of five prehistoric archaeological sites located along the south shore of Ushki Lake, an abandoned meander of the Kamchakta River less than 200 km inland from the river's outlet to the Pacific Ocean (Fig. 1). N.N. Dikov discovered the main site, Ushki-1, in the early 1960s and excavated there for nearly 30 years, into the 1990s (Dikov, 1968, 1970, 1977, 1979, 1993). At Ushki-1

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[1] All age estimates in this paper are presented in calendar years ago (cal BP), with ^{14}C dates having been calibrated using Calib 6.0 and the IntCal09 calibration curve (Reimer et al., 2009).

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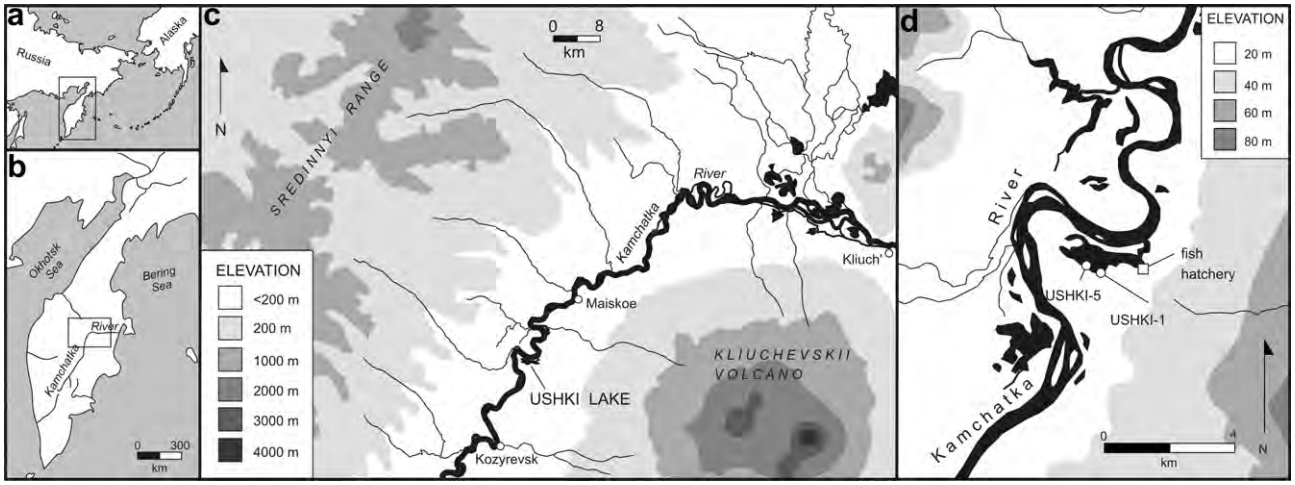

Fig. 1. The Ushki sites are located in the central Kamchatka peninsula of northeastern Russia (a–b), along the south shore of Ushki Lake in the Kamchatka River valley (c–d).

Dikov identified seven stratigraphically separate cultural layers, the two lowest of which were initially radiocarbon (^{14}C) dated to the late Pleistocene. Layer 6, the upper of the two late-Pleistocene occupations, dated to about 12,600 calendar years before present (cal BP) and contained wedge-shaped microblade cores, microblades, and burins, common artifacts among Beringian sites. Layer 7, the basal occupation, dated to about 17,000 cal BP (Table 1) and contained a unique assemblage of bifacially worked stemmed points and flake tools (Dikov, 1977, 1979; for English-language summaries see Goebel and Slobodin, 1999; Graf and Goebel, 2009; Kuzmin et al., 2008; Slobodin, 2001, 2006). Dikov recognized the obvious importance of the layer 7 industry to the story of the peopling of the Americas, because it contained bifacially worked artifacts dated to about 3–4000 years before the time of Clovis (Dikov, 1978, 1979, 1985). After Dikov's death in 1996, M. Kir'iak (also known as Dikova) continued to excavate there into the early 2000s (Kir'iak, 2002).

In the Year 2000 Goebel and Waters revisited the Ushki sites with Kir'iak to independently establish the Paleolithic layers' stratigraphic contexts and chronometric ages, and to investigate the character of their assemblages. Stratigraphically, Goebel et al. (2003) confirmed that cultural layers 6 and 7 occurred in fine-grained, rapidly accumulating, overbank floodplain deposits that were stratigraphically separated by as much as 30 cm of culturally sterile silt and clay. Archaeologically, they found that layer 6 was characterized by distinctive wedge-shaped microblade cores and microblades, burins, and lanceolate-shaped bifaces, while layer 7 was characterized by small bifacial points with stems, flake tools, and stone beads. In their excavations at Ushki-5, layer 6 was found also to contain a well-preserved hearth and semi-subterranean dwelling feature, while layer 7 contained stained living floors with unlined and diffuse hearth features. Chronologically, charcoal from layer 6 repeatedly dated (by AMS ^{14}C) to about 11,500–12,500 cal BP, while charcoal from layer 7 repeatedly dated to 12,900–13,200 cal BP. Dated charcoal came from two separate profiles at Ushki-1 (Fig. 2) and two separate excavations at Ushki-5. In each of these four areas Kir'iak, who had many years of experience excavating at Ushki, participated in describing the stratigraphic profiles and delineating stratigraphic boundaries of cultural layers 6 and 7. Further, in both excavations at Ushki-5, Kir'iak and Goebel's team found diagnostic artifacts of the two complexes.

The Year 2000 results confirmed Dikov's observations in every way but one – Goebel et al.'s (2003) seven ^{14}C ages for layer 7 were about 4000 years younger than Dikov's original dates. The new dates suggested that layer 7 at Ushki did not date to 17,000 cal BP but instead dated to 13,000 cal BP, and that layer 7 was too young to be ancestral to other late-glacial American bifacial industries like Clovis (cf. Waters and Stafford, 2007) and Nenana (cf. Hamilton and Goebel, 1999).

Goebel et al.'s (2003) analysis of the Ushki sites has been criticized for unsatisfactorily explaining the discrepancy between Dikov's old dates and the new young dates for layer 7. They argued that the charcoal samples which produced the old dates had come from a human burial pit, and "because the grave was dug into older sediments containing charcoal, the older sediment and associated charcoal filled the grave and led to the erroneous ages" (Goebel et al., 2003: 505). Kir'iak (2005) (see also note 19 in Goebel et al., 2003) disagreed, instead raising doubts about some of the age estimates Goebel et al. (2003) reported, especially those from the Ushki-1 profiles, since they were not associated with artifacts, and the Ushki-5 block excavation, where a layer-6 dwelling had been dug into layer 7, partially disturbing the earlier living floor. Others have continued to use the early layer-7 dates in their ^{14}C analyses (Fiedel and Kuzmin, 2007: 755; Kuzmin and Keates, 2005; Kuzmin and Rybin, 2005), arguing that the ^{14}C age of about 14,300 ^{14}C BP ($\sim$17,000 cal BP) "may still be valid for some parts of this site cluster" (Kuzmin and Rybin, 2005: 47), and that the old dates should stay in the Siberian ^{14}C database until "new full-scale excavations are conducted" (Kuzmin and Keates, 2005: 779).

Needless to say, continued studies of Ushki, especially layer 7, are needed to establish the geochronology of this very important Beringian Paleolithic site. For this reason, since 2003 we and others have continued to date samples from the Ushki Paleolithic layers. Ponkratova (2007) reported new results for Ushki-5 – 11,320 ± 30 (UCIAMS-32198)[2] and 11,060 ± 25 ^{14}C BP (UCIAMS-32199), on hearth charcoal from layers 6 and 7, respectively (Table 1), and here we present new dates for Ushki-1. The new dates come from archaeological features excavated at Ushki-1 more than 20 years

[2] The provenience of date 11,320 ± 30 (UCIAMS-32198) is unclear. Ponkratova (2007) assigns it to layer 7, but documentation associated with the sample when it was given to Goebel and Waters indicated that it originated from the layer-6 living floor at Ushki-5, in between different dwelling features (I. Ponkratova, pers. commun., 2006). For this reason, here we refrain from including it in the series of dates obtained for layer 7.

Table 1
Previous ^{14}C dates for layer 7 of the Ushki-1 and Ushki-5 sites.

Lab number	^{14}C age	1-σ age (cal BP)	2-σ age (cal BP)	Material dated	Method	Provenience	Ref.
Ushki-1							
AA-45708	10,810 ± 75	12,602–12,758	12,576–12,884	Charcoal	AMS	Geologic profile A	4
AA-45709	10,850 ± 320	12,414–13,130	11,822–13,385	Charcoal	AMS	Geologic profile A	4
AA-45710	10,675 ± 75	12,551–12,661	12,425–12,741	Charcoal	AMS	Geologic profile A	4
AA-45716	11,050 ± 75	12,843–13,086	12,703–13,115	Charcoal	AMS	Geologic profile B	4
GIN-167[a]	13,600 ± 250	16,270–17,032	15,430–17,220	Charcoal	Conventional	Human burial pit[c]	1
GIN-168	14,300 ± 200[b]	17,114–17,653	16,930–17,907	Charcoal	Conventional	Human burial pit[c]	5
LE-3695	11,360 ± 330	12,885–13,577	12,599–13,870	Charcoal	Conventional	Sqs. m7, m8[d]	6
LE-3697	11,120 ± 500	12,432–13,600	11,407–14,057	Charcoal	Conventional	Sqs. m (−3), m (−4)[d]	6
MAG-522	13,800 ± 500	16,069–17,613	15,091–18,029	Charcoal[e]	Conventional	Not reported	3
MAG-550[f]	14,300 ± 800	16,588–18,558	15,003–19,263	Charcoal[e]	Conventional	Not reported	2
MAG-637	9750 ± 100	10,871–11,264	10,755–11,390	Charcoal	Conventional	a12, a13, b12, v13, g12[g]	7
Ushki-5							
AA-41388	11,005 ± 115	12,743–13,067	12,645–13,125	Charcoal	AMS	Hearth, sq. B1	4
AA-41389[h]	11,050 ± 75	12,843–13,086	12,703–13,115	Humates	AMS	Hearth, sq. B1	4
CAMS-74639[i]	11,330 ± 50	13,156–13,271	13,109–13,320	Charcoal	AMS	Sq. A15 (2000 test pit)	4
UCIAMS-32199	11,060 ± 25	12,896–13,077	12,759–13,098	Charcoal	AMS	Near hearth, Sq. G (−3)	8

References: 1, Cherdyntsev et al. (1969); 2, Dikov (1980); 3, Dikov and Titov (1984); 4, Goebel et al. (2003); 5, Kuzmin (1994); 6, Lisitsyn and Svezhentsev (1997); 7, Lozhkin and Parii (1985); 8, Ponkratova (2007).

[a] Dikov (1977) and Dikov and Titov (1984) later reported GIN-167 as 14,300 ± 200, but here we adhere to the original report of the date by Cherdyntsev et al. (1969).

[b] This date is problematic, in that it was never properly reported by N. Dikov. It appeared first in Dikov (1969) but with no lab number. Then Dikov (1977, 1980), Shilo et al. (1979), and Dikov and Titov (1984) reported it as GIN-167; however, as noted above, this contradicts the report of Cherdyntsev et al. (1969), which presents GIN-167 as 13,600 ± 250. Later, Dikov (1986, 1990) indirectly seems to have cleared up the matter by assigning the date of 13,600 ± 250 to GIN-167; to us this implies that the date of 14,300 ± 200 is indeed GIN-168. Kuzmin (1994) paired the two GIN dates as we have here.

[c] Provenience is reported by Dikov (1977).

[d] Provenience for this sample was logged in the LE laboratory catalog (G. Zaitseva, pers. commun., 2009) but not previously reported in print.

[e] Reported in unpublished MAG catalog of dates.

[f] Dikov and Titov (1984) later reported MAG-550 as 14,200 ± 700, while Dikov (1985) later reported this sample as 14,300 ± 200.

[g] In Dikov's papers, the provenience of these samples was logged as o12, o13, b12, v13, g12; however, this cannot be because Dikov did not excavate squares o12 and o13 until some years later (Fig. 2). More likely the correct squares are a12 and a13, which are adjacent to the others listed for the samples' provenience.

[h] This sample was a humate pair for sample AA-41388.

[i] This sample corresponds to SR-5810 (the sample number assigned by Stafford Research, Inc., who prepared the sample).

ago. They clearly show that Goebel et al.'s (2003) revised age estimate for layer 7 at Ushki was correct – that the earliest human occupations at Ushki date to about 13,000 cal BP. They also imply that the earlier series of older dates (in excess of 16,000 cal BP) should be disregarded, at least until they can be independently confirmed.

2. Sample descriptions and provenience

On March 29, 2008, while organizing and inventorying the Ushki collection at the Northeast Interdisciplinary Science Research Institute, Far Eastern Branch of the Russian Academy of Sciences, Magadan, one of us (Slobodin) and A. Lebedintsev (Head of the Laboratory of History and Archaeology at the Institute) encountered a collection of curated charcoal samples from N. Dikov's early excavations at Ushki-1. Among them were four samples recorded to have come from features excavated in layer 7. We numbered these samples 1–4. Samples 1–3 were stored in small glass jars (Fig. 3a and b) while sample 4 was curated in a metal can (Fig. 3c). All were hand-labeled with their context and year of excavation. All were from hearths excavated during the 1980s, but their recorded level of provenience varied. Sample 1 came from squares m7 and m8, excavated in 1989. The charcoal came from a feature described by Dikov (1993) as a bone–charcoal mass, likely a hearth, situated within dwelling feature 10 (Fig. 2). Samples 2 and 3 were also recovered during Dikov's (1989) excavation, specifically squares l–m/(−4)–(−3), from a bone–charcoal mass interpreted as a hearth situated within dwelling feature 11. Dikov (1993) described dwellings 10 and 11 as follows:

> One of the three [dwelling features] belonging to the external row of houses, namely dwelling number 11, was investigated in 1989 and preserved in view as a round (8 × 6 m) charcoal area with two extensive hearth-like stains with specks of burnt bone mass, eight stemmed points, other artifacts, and waste flakes from stone-working activities. It was situated alongside the double dwelling number 9. Another dwelling (no. 10) investigated in 1989, 10 m to the east, was marked by still another round charcoal stain (9 × 10 m), with one large (1.7 × 1.2 m) central hearth stain with scattered specks of bone mass and many stone artifacts (including one stemmed point) and flakes (pp. 11–16).[3]

The precise provenience of sample 4 was not recorded on its container; however, from its label we learned that it was excavated in 1982. We consulted Dikov's unpublished field report for the 1982 excavations (Dikov, 1983) to reconstruct what we could of this sample's provenience. In the report, Dikov wrote that in 1982 there were two excavations, western and eastern. In the eastern excavation that year, Dikov did not recover any layer 7 remains (Dikov, 1983: 14), but in the western excavation he found several hearths, and he reported that charcoal samples were taken from each of them (Dikov, 1983: 11). This western excavation focused on squares b–z/1–7 (Fig. 2), and specifically, Dikov (1983) reported that in this area in 1982, layer 7

> turned out to be extremely poor in findings and contained just one large charcoal stain with two hearths (70 and 80 cm in diameter), a piece of red hematite, and a flake. Two locations [sic, meters] from this stain, which apparently was the foundation of a hut-like dwelling, another hearth (80 × 40 cm) was found, without any artifacts or flakes. Besides this, there were

[3] Goebel translated into English the Russian texts quoted in this paper.

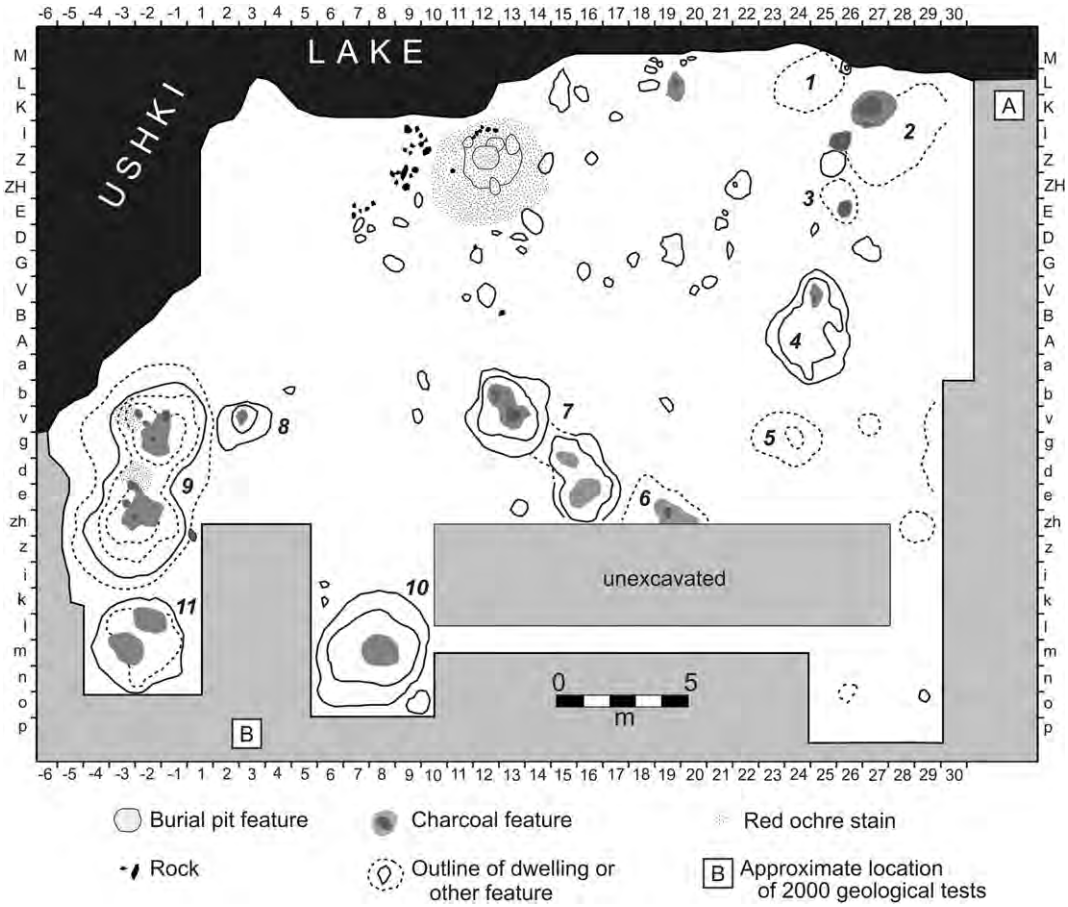

Fig. 2. The layer-7 living floor at Ushki-1 consisted of 11 discernible dwelling features (numbered 1–11 on this map, after Dikov, 1993) and a human burial pit feature saturated with red ochre, located in the north-central area of the excavation. The samples dated in this study came from dwelling features 8, 10, and 11, in the western area of the site. The map also shows approximate locations of the two stratigraphic profiles. Goebel et al. (2003) sampled for dating in 2000.

two more chert flakes and a small pile of small stones 6–10 cm thick in cross section (p. 14).[3]

Thus, it is clear that the fourth charcoal sample came from a hearth in the western area of the site, somewhere within squares b–z/1–7. The above description compares favorably with the excavation plan Dikov (1993) presented and that we have redrawn in Fig. 2. Sample 4 most likely originated from one of the two hearth stains in dwelling 8, or from the small charcoal stain located about 2 m northeast of dwelling 8.

With this information, we can clearly tie the four charcoal samples to specific hearth/dwelling features excavated from cultural layer 7 at Ushki-1. Moreover, these features were intact, not having been disturbed by later digging of semi-subterranean dwellings during the layer-6 occupation.

3. Radiocarbon dating procedures and results

The curated Ushki-1 charcoal samples were pretreated at Stafford Research Laboratories, Inc. The charcoal pieces were structurally sound, with recognizable wood grain. Dating methods followed those described in Stafford et al. (1991) and Waters and Stafford (2007). Briefly, dating was based on using an acid–base–acid technique that comprises (1) treatment in hot 6 N HCl until solution colors became clear and colorless; (2) repetitive extractions in hot 1 M KOH until solutions were clear and colorless; (3) two wet chemical oxidations in hot 18 M nitric acid for 30 min each; and (4) washing in 0.05 N HCl. Following combustion in a sealed quartz tube, CO_2 was separated and converted to graphite for AMS ^{14}C measurement at the W.M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory at the University of California-Irvine. The rigorous base and nitric acid pretreatment steps eliminated any rootlets, humates, or other carbon not converted into charcoal during the ancient hearth's burning. Although yields were much less than 50% of the original samples, the outcome was extremely pure charcoal devoid of any presently known contaminant (T. Stafford, pers. commun., 2009).

Resulting AMS ^{14}C determinations (isotopically corrected) and one-sigma and two-sigma calibrated ranges are presented in Table 2. For dwelling feature 10 (squares m7 and m8), hearth charcoal yielded an age of 11,185 ± 25 ^{14}C BP (UCIAMS-53553), and for dwelling feature 11 (squares l–m/(−4)–(−3)), hearth charcoal yielded ages of 11,210 ± 25 ^{14}C BP (UCIAMS-53554) and 11,205 ± 25 ^{14}C BP (UCIAMS-53556). The fourth sample, which came from a hearth feature likely discovered in dwelling feature 8 in the western sector of the Ushki-1 excavation (squares b–z/1–7), yielded an age of 11,220 ± 25 ^{14}C BP (UCIAMS-53556).

We calibrated these four ages using Calib 6.0, which is based on the IntCal09 dataset (Reimer et al., 2009). All four estimates overlap at one-sigma, and two-sigma age ranges indicate that all three features formed about 13,000–13,200 cal BP (Table 1). This calibration and other calibrated ages in this paper, however, should be considered provisional because calibrated dates of this age derived from Calib 6.0 are based on Cariaco Basin marine data (not tree-ring data) (Reimer et al., 2004), a record which has recently been shown to produce calibrated dates as much as 240 years too old during this time period (Hua et al., 2009; Muscheler et al., 2008).

Fig. 3. Glass jars and metal can containing charcoal samples submitted for radiocarbon analysis. (a) Sample from dwelling 10; (b) sample from dwelling 11; and (c) sample presumably from dwelling 8. Provenience data are written in Russian on the containers' labels.

4. Discussion

The four new AMS ^{14}C dates presented here clearly show that the three dated features from cultural layer 7 at Ushki-1 date to about 11,100–11,200^{14}C BP, or 13,000–13,200 cal BP.

These new results conform well to earlier results presented by Goebel et al. (2003). For Ushki-1, the new dates overlap at one-sigma the layer-7 date obtained from geologic profile B (12,843–13,086 cal BP [AA-45716]) and one of the three dates from geologic profile A (12,414–13,130 cal BP [AA-45709]); however, they do not overlap even at two-sigma the two other dates from profile A (12,602–12,758 [AA-45708] and 12,551–12,661 cal BP [AA-45710]), which are significantly younger. Those four samples were not from hearth features, so it could be that the two younger samples do not represent the age of the layer-7 occupation but instead the deposits that immediately sealed it. For Ushki-5, the new dates overlap (at two-sigma) all four of Goebel et al.'s (2003) AMS dates for layer 7, as well as the date more recently reported by Ponkratova (2007) of 12,896–13,077 cal BP (UCIAMS-32199) (Table 1). Clearly the Ushki-5 layer-7 hearths are very close in age to the newly dated hearths at Ushki-1.

The ~13,000 cal BP age estimate for layer 7 at Ushki is further confirmed by three conventional dates obtained by ^{14}C laboratories in Russia (Institute of the History of Material Culture, Russian Academy of Science, St. Petersburg, and Northeast Interdisciplinary Science Center, Russian Academy of Science, Magadan). These include two published dates of 11,360 ± 330 (LE-3695) and 11,120 ± 500 ^{14}C BP (LE-3697) (Lisitsyn and Svezhentsev, 1997), which were produced in 1990, and one previously unpublished date of 11,650 ± 100^{14}C BP (MAG-594) (unpublished MAG catalog of radiocarbon dates), which was produced in 1980. Dikov never reported these dates in his published papers or unpublished reports on Ushki, presumably because he interpreted them to be too young. Nonetheless, he did provide respective ^{14}C laboratories with important provenience information, which we were able to retrieve from the laboratories' sample catalogs. LE-3695 came from squares m7 and m8, while LE-3697 came from squares m(−3) and m(−4). These are clearly the same hearth features for which we present new AMS dates in this paper, and the LE results and our results obviously overlap at one-sigma. MAG-594 came from squares a12, b12, and v12 and hence relates to dwelling 7. Thus, there are now 15 ^{14}C dates on charcoal from a variety of features and profiles across the two main Ushki sites (Ushki-1 and Ushki-5) that put the age of the layer-7 occupation at about 13,000 cal BP, nearly 4000 years later than the originally reported age of ~17,000 cal BP (cf. Dikov, 1977).

What of Dikov's original series of old dates, which suggested layer 7 at Ushki dated in excess of 16,000 cal BP? Of course we must consider the possibility that these dates are also accurate, that the layer-7 occupation could have spanned several thousand years (cf. Goebel et al., 2003: note 19). Kuzmin and Keates (2005: 779) have argued this, because it is possible both the old and young series of dates are correct, and because their prescribed analytical method of counting "occupation episodes" requires the use of the full suite of dates. To calculate number of occupation episodes, they indiscriminately group individual ^{14}C dates into respective millennia

Table 2
New AMS ^{14}C dates for layer 7 of the Ushki-1 site.

Lab number	^{14}C age	1-σ age (cal BP)	2-σ age (cal BP)	Material dated	Provenience	δ^{13}C ‰
UCIAMS-53553	11,185 ± 25	12,974–13,164	12,903–13,207	Charcoal	Hearth in dwelling feature 10	−22.5
UCIAMS-53554	11,210 ± 25	13,084–13,183	12,937–13,254	Charcoal	Hearth in dwelling feature 11	−26.4
UCIAMS-53555	11,205 ± 25	13,079–13,185	12,931–13,243	Charcoal	Hearth in dwelling feature 11	−25.8
UCIAMS-53556	11,220 ± 25	13,091–13,184	12,952–13,271	Charcoal	Hearth in or near dwelling feature 8	−25.2

Table 3
Previously obtained but unpublished conventional ^{14}C dates for layer 7 of the Ushki-1 site.

Lab number	^{14}C age	1-σ age (cal BP)	2-σ age (cal BP)	Material dated	Provenience	Ref.
LE-3024	9960 ± 100	11,250–11,607	11,202–11,948	Charcoal	Hearth, sqs. b13, v13	1
MAG-594	11,650 ± 100	13,382–13,626	13,300–13,740	Charcoal	Sqs. a12, b12, v12 (dwelling 7)	2

References: 1, LE catalog of radiocarbon dates (G. Zaitseva, pers. commun., 2009); 2, MAG catalog of radiocarbon dates (A. Lozhkin, pers. commun., 2010).

and then count the number of millennia that are represented. If all of the ^{14}C dates for a cultural layer fall within a thousand year span of time (e.g., 17,000–18,000^{14}C BP) then they are grouped together into a single episode and counted once, but if a single cultural layer has yielded dates spanning more than one millennium (e.g., 14,500 ± 250 and 13,500 ± 300^{14}C BP), they are treated as representing two occupation episodes and counted twice. The reasoning behind this is the assumption that Paleolithic components could potentially represent palimpsests of multiple occupations. Following this method, if we consider all of the uncalibrated ^{14}C dates from Ushki-1, layer 7 (as shown in Fig. 5 and Tables 1–3), we would conclude that the cultural layer represents five occupation episodes: 9000–10,000, 10,000–11,000, 11,000–12,000, 13,000–14,000, and 14,000–15,000^{14}C BP. The implication of these results would be that layer 7 represents a series of occupations spanning as much as 5000 years.

There are five reasons, however, not to indiscriminately accept all of the Ushki layer-7 dates and apply the occupation episode method to interpret the age of the layer:

(1) The geological deposits that contain the early Ushki cultural layers represent rapidly aggrading overbank floodplain deposits (Goebel et al., 2003), and their character suggests that deposition could not have been drawn out over 5000 years, and that the layer-7 living floor could not have lain open on the surface for more than a few centuries.
(2) Two samples of dispersed charcoal from the floodplain deposits a few centimeters below the base of layer 7 at Ushki-1 (from geological profiles A and B) yielded AMS ages of 13,600–13,800 cal BP (Goebel et al., 2003). Although admittedly dating of dispersed charcoal samples can be problematic, but along with the other evidence presented here, these suggest that layer 7 could not date to before this time, certainly not to 16,000–17,000 cal BP.
(3) At least two of the early dates (GIN-167 and GIN-168) originated from a human burial pit (Dikov, 1977) (Table 1), and perhaps the charcoal used to produce these two dates originally came from older deposits that had been secondarily emplaced in the pit as it was being filled during the time of the layer-7 occupation (Goebel et al., 2003). Humans dug the burial pit to a depth of 70 cm below the contemporaneous layer-7 living surface (Fig. 4) (Dikov, 1993: 10), and in doing so they obviously disturbed older deposits from which the dated charcoal could have come. Further, Dikov (1977: 51) reported that "judging by stratigraphy, the burial is assignable to the late stage of cultural layer 7: the hearths of the site (near the burial) are overlain by fill from the burial pit". This implies that the age of the burial should be younger, not older, than surrounding hearths and dwelling features.
(4) Provenience data for the other two early samples (MAG-522 and MAG-550) were not reported, and our examination of Dikov's archives and the MAG catalog of radiocarbon dates has failed to turn up any record of their origin. In our opinion, without this information the value of these two dates is diminished significantly, because they could have come from the human burial pit or one of the other features dated to another lab to only ~13,000 cal BP.
(5) Multiple samples of charcoal from Ushki-1 and Ushki-5 have demonstrated that cultural layer 6, which overlies layer 7, dates to about 10,350^{14}C BP (~12,000–12,350 cal BP) (Goebel et al., 2003), indicating that the dates of 9750 ± 100^{14}C BP (11,250–11,607 cal BP) (MAG-637) and 9960 ± 100^{14}C BP (11,250–11,607 cal BP) (LE-3024) for layer 7 (Table 1) should be dismissed.

Beyond what we have presented here, the only way to fully resolve the questions surrounding the four old dates from layer 7 at Ushki-1 would be to redate the features from which the samples came. This may be impossible, because (1) no curated charcoal from the burial feature exists, (2) Dikov did not recover datable human remains from the burial pit (they were poorly preserved and not collected (Dikov, 1977)) and (3) we do not know the origins of the

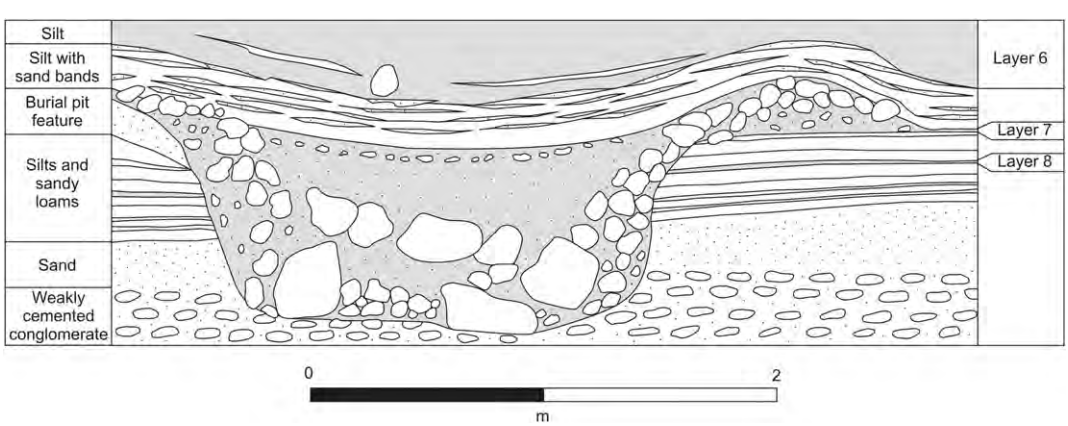

Fig. 4. The human burial pit feature from layer 7 at Ushki-1 was excavated to a depth of about 70 cm below the layer-7 living floor, through at least 12 stratigraphic layers (after Dikov, 1993). It contained a mixture of volcanic bombs, sand, and silt from layers underlying layer 7. We presume that some of the discordantly old dates of layer 7 came from this mixed context (sediment descriptions from Dikov, 1977).

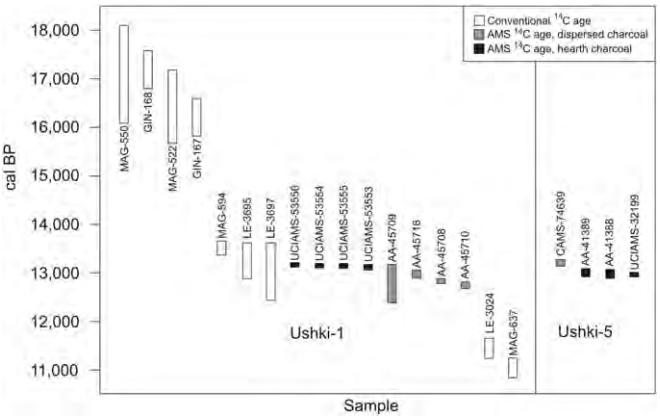

Fig. 5. Accelerator radiocarbon ages (one-sigma ranges), shown here in calendar years ago (or cal BP), for layer 7 at Ushki-1 cluster around 13,000 cal BP, while older conventional radiocarbon ages range between 16,000 and 18,000 cal BP. Focusing just on dated hearth features tells us that layer 7 likely dates specifically to 13,000 cal BP; however, using Kuzmin and Keates's (2005) "occupation episode" method of determining the number of occupations represented, one would have to conclude that layer 7 represents five episodes. This latter interpretation, though, runs counter to contextual evidence – that the thickness of layer 7, away from the human burial pit feature, is less than 5 cm (see Fig. 4), the age of underlying layer 8 is only 13,900 cal BP, and the rate of deposition of dated late-Pleistocene layers was rapid, perhaps as much as 4 cm/century.

early MAG dates. Continued dating of deposits underlying layer 7 at Ushki-1 and Ushki-5, however, could help better define a lower-limiting age for the sites' earliest cultural occupation.

5. Conclusions

The new results bear on several important aspects of current research in the Pleistocene archaeology of Beringia and the Americas: (1) building of regional ^{14}C chronologies to reconstruct when and how modern humans colonized northern environments; (2) explaining the presence of non-microblade, bifacial point industries in Beringia around 13,000 cal BP; and (3) developing a Pacific coastal theory of human dispersal from northeast Asia to northwest North America during the late-glacial.

First, the complete series of dates for layer 7 at Ushki illustrates the vagaries of interpreting ^{14}C dates from Upper Paleolithic sites. Radiocarbon chronologies (especially Paleolithic chronologies) are often riddled with bad dates – dates that contradict stratigraphic or other contextual evidence, have large standard errors, are derived from materials that are notorious for yielding erroneous ages, or were obtained using pretreatment procedures that do not meet today's standards (in the last regard, especially in the dating of bone) (Graf, 2009; Pettitt et al., 2003; Waters and Stafford, 2007). As the case presented here illustrates, to objectively evaluate the full suite of dates from a Paleolithic site we need to know each date's specific pedigree – the sample's provenience, its geologic context, its association with archaeological materials and other dated specimens, and the procedures through which it was prepared and dated. For layer 7 at Ushki, 15 of 21 dates fall around 12,600–13,600 cal BP, while four are significantly older and two are significantly younger. Lower- and upper-limiting ages (13,500–14,000 and 12,000–12,350 cal BP, respectively) that bracket layer 7 suggest that the older and younger dates for layer 7 are inaccurate, and for this reason we dismiss them from further consideration, at least until it can be shown how ca. 17,000 cal BP or 11,000 cal BP cultural features could be preserved on a 13,000-cal-BP living floor. Some will argue that the lack of information about the origins of two of the four older dates means we should not be so hasty in rejecting them; however, as Kuzmin and Keates (2005) have pointed out, dates are not just data, so each individual date needs to be carefully reported so that we can independently assess its accuracy. The dating saga at Ushki is a prime example of why we should not uncritically accept all dates (without evaluation) from a Paleolithic archaeological component. Indiscriminate use of dates can lead to faulty and misleading interpretations of chronological data. Given that these kinds of problems recur at many Paleolithic sites, one might wonder about the utility of regional-scale northeast Asian and Beringian analyses of ^{14}C dates (e.g., Brantingham et al., 2004; Dolukhanov et al., 2002; Fiedel and Kuzmin, 2007; Fiedel et al., 2007; Goebel, 1999; Graf, 2005, 2009; Kuzmin and Keates, 2005; Kuzmin and Tankersley, 1996; Potter, 2008; Ugan and Byers, 2007). To be beneficial, such studies should carefully and consistently document how individual dates and sites were systematically treated in analyses (cf. Graf, 2009).

Second, the new dating results matter in terms of understanding the process of human dispersal across Beringia during the late Pleistocene. At 13,000 cal BP, layer 7 at Ushki is still one of the earliest dated late-glacial human occupations in western Beringia. Certainly humans could have been in western Beringia earlier in the late-glacial, but we know of no sites unequivocally dating between about 29,000 cal BP (the age of the Yana RHS site (Pitulko et al., 2004) and 13,000 cal BP. Berelekh has long been considered a possibility (Goebel, 2004; Goebel and Slobodin, 1999; Hoffecker and Elias, 2007; Mochanov, 1977), but Pitul'ko's recent work at the site suggests that its Paleolithic occupation is not significantly older than our interpreted age for layer 7 at Ushki (Pitul'ko, 2008). In eastern Beringia the earliest clear evidence of humans comes from Swan Point, where a wedge-shaped core and microblade industry has been dated unequivocally to just before 14,000 cal BP (Holmes, in press). Besides this key site, the evidence from across Beringia signals a strong human presence during the late Allerød interstadial, ca. 13,000 cal BP. Dating to this time are the Nenana complex and lowest layers at Broken Mammoth[4] in central Alaska, certain occupations of the Sluiceway-Tuluaq complex in northwest Alaska, layer 7 at Ushki, and possibly Berelekh (Hamilton and Goebel, 1999; Hoffecker and Elias, 2007; Hoffecker et al., 1993; Pitul'ko, 2008; Rasic and Gal, 2000; Yesner, 2001).[5] The surprising feature of these sites is that all of them are characterized by stone bifacial points instead of microblades.[6] Microblades became common in the region near the onset of the Younger Dryas (~12,800 cal BP) and continued to be used during every millennium of the Holocene in Alaska until about 1000 cal BP (Potter, 2008). The lack of microblades during the 14,000–13,000 cal BP millennium could be a product of archaeological sampling or site-specific human activities (as many researchers have pointed out over the years (Bever, 2001; Colinvaux and West, 1984; Dumond, 1980; Hoffecker, 2001; Holmes, 2001; Hopkins et al., 1982; West, 1996), but it could also mean that significant and important cultural variability had emerged in Beringia as early as 13,000 cal BP and possibly earlier. This variability fits some of the expectations of recent genetic models of the peopling of Beringia

[4] The lowest cultural occupation at Broken Mammoth has recently yielded a teardrop-shaped bifacial point similar to those from sites of the Nenana complex and Healy Lake (D. Yesner, pers. commun., 2009).

[5] Some would add Mesa to this list, but we follow Hamilton and Goebel (1999) and Hoffecker and Elias (2007), who have argued the site dates to the next millennium.

[6] Nogohabara-1 may contradict this pattern (Odess and Rasic, 2007), but Holmes et al. (2008) have argued that this sand-dune site is likely mixed and the association of the old dates and artifacts cannot be trusted. Also, the microblades from the lowest component at Broken Mammoth reported by Krasinski (2005) have turned out to be narrow biface-thinning flakes mislabeled in the field (D. Yesner, pers. commun., 2008).

and the Americas (Mulligan et al., 2008; Perego et al., 2009; Tamm et al., 2007), and it could be that the early Ushki culture, with its small stemmed bifacial points and simple flake tools, represents one of several late-glacial Beringian populations that ultimately gave rise to some early American populations, or at least to some of the genetic diversity documented among modern Native Americans. In this respect, Dikov's (1979) original hypothesis that the early Ushki culture was a source for some of the first archaeological complexes of far-western North America may not have been far off the mark.

Third, as it is situated in central Kamchatka less than 200 km from the Pacific shore, layer 7 at Ushki still represents the earliest human occupation of the Beringian Pacific Rim. Besides hunting, its inhabitants were fishing for salmon (Goebel et al., 2003; Kir'iak, 2002). This riverine focus could have facilitated a late-glacial dispersal along the southern coast of Beringia, through southeast Alaska to California and beyond. Although direct archaeological evidence for such a coastal dispersal is still lacking, large stretches of the south Beringian coast appear to have been ice-free by 13,000 cal BP, perhaps even by 14,000 or 15,000 cal BP (Clague et al., 2004; Dyke, 2004; Fedje et al., 2004; Kaufman and Manley, 2004). Further, analyses of modern human molecular genetics imply a Pacific coastal migration (Fagundes et al., 2008b; Fix, 2002, 2005), and ancient DNA studies are beginning to show a connection between late-Pleistocene populations of the far-west of North America, from Alaska south to Oregon (Gilbert et al., 2008; Kemp et al., 2007). Small stemmed points similar in size and morphology to the early Ushki points may date to the latest Pleistocene and earliest Holocene on the Channel Islands of California (Erlandson and Jew, 2009), while at Buhl, Idaho, isotopic analyses of human remains associated with a stemmed point and dating to ~12,600 cal BP indicate a diet rich in marine resources, presumably river-running salmon (Green et al., 1998). Thus, many signs are pointing toward a coastal migration for at least some of the Americas' founding populations, but we still lack critical evidence from southern Beringia indicating such an event took place, not just archaeological sites unequivocally dated to before 13,000 cal BP, but also human remains and ancient DNA evidence from Beringia's Allerød-aged sites. Perhaps Ushki is the best place to look for the early human remains, given prior discoveries of human burial pits and, from cultural layer 6, preserved human dental and skeletal material (Dikov, 1993).

Finally, despite being redated to only ca. 13,000 cal BP, we want to reiterate that layer 7 at Ushki still represents the earliest well-dated late-glacial human occupation in western Beringia. Given that earlier late-glacial sites have been found in Alaska (the lowest layers at Swan Point and Broken Mammoth, for example) and the Americas south of the Canadian ice sheets (Goebel et al., 2008), clearly we still lack an important part of the late Paleolithic record of Kamchatka and Chukotka. Future discoveries in the region will certainly refine, likely change, many of our interpretations today.

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