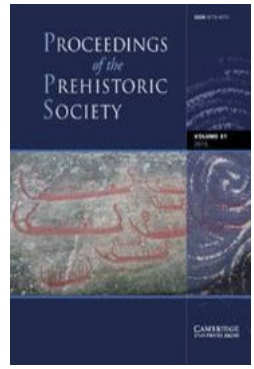

New AMS Dating of Bone and Antler Weapons from the Shigir Collections Housed in the Sverdlovsk Regional Museum, Urals, Russia

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New AMS Dating of Bone and Antler Weapons from the Shigir Collections Housed in the Sverdlovsk Regional Museum, Urals, Russia

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This paper presents new AMS dating of organic finds from the Shigir (Shigirsky) peat bog, located in the Sverdlovsk Province, Kirovgrad District of the Urals. The bog is located immediately south of the river Severnaya Shuraly, with the Urals to the west. Intermittent survey and excavation has been undertaken at this location since 1879, resulting in the recovery of in excess of 3000 cultural artefacts, including oars, sculptures of birds, snake figurines, wooden skis, arrowheads, and fish hooks. The dates presented here indicate that not only is there a long duration of human use of the wetlands at Shigir, but that the artefact forms also appear to have a significant duration of use throughout the earlier prehistoric periods considered here.

Keywords: AMS dating, organic preservation, bone and antler objects, waterlogged deposits, Russia, Mesolithic, Neolithic

The significance of waterlogged deposits for the preservation of the organic part of the cultural record cannot be overstressed (Lillie & Ellis 2007, 3). In fact, numerous studies have highlighted the significance of waterlogged burial environments in relation to our understanding of earlier Holocene hunter-fisher-forager societies, and also the general importance of wetlands when studying human–landscape interactions in the prehistoric and historic periods (eg, Chairkina *et al.* 2013; Coles & Coles 1986, Lillie & Ellis 2007; Louwe Kooijmans 1987; Purdy 2001 amongst many others). In Eastern Europe the literature on organic preservation in wetlands is extensive and the exceptional nature of the preservation at sites like Shigir, a peat bog, located in the Sverdlovsk Province, Kirovgrad District of the Urals, indicates that the potential these sites have for enhancing our understanding of human–landscape interactions and vegetation changes across the Holocene is considerable (eg Burov 1989; 2001; Chairkina 2011; Oshibkina 1989; Savchenko 2007; Zagorska & Zagorskis 1989; Zaretskaya *et al.* 2012; Zhilin 1999; 2003; 2004; 2006; 2007; Zhilin *et al.* 2002; 2012).

The anthropomorphic wooden statue known as the Shigir Idol (Lillie *et al.* 2005) has yielded three conventional radiocarbon dates (GIN-9467/1, 8680 ± 140 BP; GIN-9467/2, 8750 ± 60 BP, & LE-5303, 8620 ± 70 BP; Savchenko 1999). A χ^2 test shows them to be statistically consistent (T' = .02; T'(5%) = 6; $\nu = 2$) and the R_Combine function in OxCal provides a weighted mean of 7840–7590 cal BC (95% probability; 8694 ± 44 BP).

The current study presents the results of new AMS determinations of organic finds from the Shigir peat bog in the Trans-Urals region of Russia (57°22'30.50"N 60°5'57.90"E). Calibration for all of the dates presented in this paper was undertaken using OxCal v.4.2 and the IntCal13 calibration program

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(Bronk Ramsey 2009; Reimer *et al.* 2013), using the intercept method (Stuiver & Reimer 1986), and these are rounded out to the nearest 10 years (following Mook 1986). All dates are expressed at the 2 σ range. As has been noted by Chairkina *et al.* (2013, 418) waterlogged peat bogs are particularly numerous in the Trans-Urals region in eastern Russia, and Shigir (or Shigirsky) is a particularly well-known location in this respect. Chairkina *et al.* (*ibid.*, 419) have previously argued that the paucity of direct dating on artefacts from the Trans-Urals, with the exception of the Shigirsky Idol, requires revision. As such the current study is aimed at further enhancing the chronological resolution of the artefactual remains from the Shigir peat bog site, which is one of two key sites in this region; the second being Gorbunovo (Chairkina *et al.* 2013; Zaretskaya *et al.* 2012, 783).

The Shigir peat bog is situated at the eastern slope of the Ural Mountains, *c.* 90 km to the north-north-west of Yekaterinburg (Fig. 1). Artefacts from the Shigir collection were gathered from a vast area of about 30 km^2, from both different locations and different depths within the wetland areas. The bog contains 68 recorded archaeological sites, the majority of which are distributed on the shores and 'islands' of the palaeo-lake, which is of Late Glacial origin, with cultural layers mainly accumulated in the deposits at the lake edge (Zaretskaya *et al.* 2012). Palaeoenvironmental studies of the lake sequence at Shigir, at the site of Varga-2, have shown that a sequence of intercalated gyttja (with organic inclusions), peaty-gyttja, and peats occurs at this location (*ibid.*, 785). Radiocarbon dating (using both conventional and AMS techniques) of the depositional sequences (peats and organic rich gyttja) has indicated that the lower mineroganic gyttja (at 310–325 cm depth) began forming at 7880 ± 350 BP (GIN-13868) or 7590–6070 cal BC. However, this date should be considered with caution as the sample was retrieved using a hand augur from a depth of over 3 m, and it is possible that contamination will have compromised the integrity of this particular date. The uppermost peat at 100 cm depth at this location has been dated to 4870 ± 40 BP (GIN-13858) or 3761–3534 cal BC.

This dating is of particular importance as the single cultural horizon at Varga-2 has produced a calibrated age range for the Early Neolithic settlement at 6020–5800 cal BC, which Zaretskaya *et al.* (2012, 791) note 'is almost identical to the age of the early phase of the Upper Volga Early Neolithic culture'. It is also important to point out at this stage in the discussion that, until recently, it was thought that settlement of the Middle Trans-Urals region did not occur prior to the later Mesolithic period because of unfavourable climatic conditions (Serikov 2000, 70–2). However, studies of environmental changes during the final Pleistocene and early Holocene (Hotinski 1977, 68–82; Panova 2001, 57) have shown that the environmental conditions across this period were, in fact, similar to those in Eastern Europe and, as such, were favourable for settlement.

HISTORY OF RESEARCH AT SHIGIR

The first attempts to date and explain the provenance of the Shigir finds were undertaken very soon after their discovery. The first researcher to study this collection, M. V. Malakhov, related these finds to the Neolithic 'sub-peat' period (Malakhov 1887, 4). In the early part of the 20th century V.Ya. Tolmachov published data on the history of discovery of the Shigir finds, and also developed a typology for the arrowheads and barbed points from this site (Tolmachov 1914; 1927). Subsequently, A.A. Bers also treated the Shigir finds as a single assemblage and related them to the 'Shigir culture', dating this culture between the 3rd millennium and the 8th–2nd centuries BC (Bers 1930, 51). Following this work P.A. Dmitriev studied the finds from both the Shigir and Gorbunovo peat bogs and dated the Shigir culture to the Bronze Age, paying attention at the same time to its origins in the Neolithic period (Dmitriev 1951, 13).

Despite Dmitriev's assumptions that the Shigir assemblages related to an homogeneous (Shigir) culture grouping, in 1940 D.N. Eding had suggested that the Shigir collection was not, in fact, a uniform assemblage of material culture artefacts and had pointed to the necessity of dividing the Shigir finds into chronological periods (Eding 1940, 33). During the 1950s some of the bone artefact types were singled out by A.Ya. Bryusov (1951, 77) and V.M. Raushenbah (1956) as being of Mesolithic and Neolithic date on the basis of analogies to known peat bog sites in Eastern Europe. Raushenbah (1956, 97–103) paid particular attention to the morphological peculiarities and colour of the bone finds, which she considered pointed to the specific layers of the peat bog from which the finds came.

Comparison has been undertaken of the Shigir bone and antler artefacts with finds from Mesolithic layers

Fig. 1.
Sites with bone artefacts in the Urals area.

at the peat bog sites of Koksharovsko-Yurjinskaya I and II, Vtoraya Beregovaya, and Varga-2, excavated over the past three decades or so, and the cave sites of Kamen Dyrovatyi, Lobvinskaya, and Shaitanskaya, as well as with finds from East European peat bog sites (eg, Serikov 1992; 2000; Chairkin & Zhilin 2005; Zhilin & Savchenko 2010a; Zhilin *et al.* 2007). These comparisons have made it possible to clarify and supplement the nature and type of the Mesolithic and Neolithic bone artefacts from the Shigir collection.

On the basis of these studies, new insights into the relative dating, and an outline scheme of development of separate categories of bone weapons in the Urals area, has been undertaken (Savchenko 2011).

On the basis of this research, it appears that Mesolithic artefacts in the Shigir collection can be reliably identified by the typological method, at least to some degree. The typologically Mesolithic material includes: intact arrowheads, of needle shape, and one-winged and two-winged forms with a thick head and a long stem; composite arrowheads of various typological groups; harpoon heads with both sparse and dense barbs; spear and lance heads; daggers; knives; and various tools. Short arrowheads with a thick head and reduced stem are typologically related to the Neolithic and Chalcolithic periods. At the same time the find of a fragment of a long flat arrowhead with two long slots in the Early Neolithic layer of the site of Vtoraya Beregovaya, Gorbunovo Moor, indicates the existence of composite arrowheads not only during the Mesolithic, but also during the Neolithic in the Urals area (Savchenko 2011, 37).

It is perhaps worth noting that some categories and types of artefacts, among them weapons, could persist relatively unchanged in terms of their form and function for millennia in antiquity. Because of this, it is worth pointing out that the chronological division of collections of stray finds based on typology and analogies, even from nearby areas, is not always reliable, and results in a rather wide chronological framework for certain artefact types. It is for this reason that the direct dating of artefacts using the AMS method is especially important for such collections; hence the current study. Here we provide both uncalibrated data and also the interpretation of the calibrated results from recent AMS dating.

As is the case with north-western Europe, examples of excavated Stone Age sites with bone artefacts in the middle Trans-Urals area are not numerous (notable exceptions include Star Carr, England, Tågerup, southern Sweden, or Tybrind Vig, Denmark). In the Baltic region, Russia, and eastern Siberia a number of studies have looked to develop both regional, and more generalised, schemes for the development of bone industries during the prehistoric periods (eg, Loze 1988; Oshibkina 1989; Rimantene 1996; Zagorska 1972; 1974; 1977; 1994; Zagorska & Zagorskis 1989; Zhilin 2001a; 2001b; 2008; 2009; 2010), and for eastern Siberia (Okladnikov 1960; Hlobystin 1976; Abramova 1979; Mochanov 1977; Vdovin & Makarov 1996; Pitulko 2001). Significantly, these studies have highlighted the asynchronous nature of the emergence and development of very similar types of bone tools and weapons over northern Eurasia.

In the light of these observations, it is clear that understanding the timing and nature of human occupation and settlement in the Middle Trans-Urals region is of considerable importance to our studies of human–landscape interactions across the Late Glacial–Holocene transition in this region as securely dated locations remain the exception. Unfortunately, stratified sites in the Shigir peat bog are severely compromised as sites of different periods and culture affinities were destroyed during gold mining activities in the late 19th–early 20th centuries, and the finds that were recovered were united into one collection. This collection includes about 3000 artefacts made from stone, bone, antler, wood, copper, bronze, and iron, and also ceramic sherds of various cultures. Bone and antler artefacts comprise more than half of this collection, and it is worth noting that only a small part of the bone artefacts represented find direct analogies among the finds from the excavated peat bog and cave sites in the Urals (mentioned above).

A number of artefacts from Shigir are kept in museums in Kazan (Republic of Tartarstan), Moscow, Saint Petersburg, Paris, and Helsinki, thus making access for research purposes less than ideal. However, the majority of the finds from this collection, comprising about 3000 objects, are kept in the Sverdlovsk regional museum (SOKM) in Yekaterinburg, and it is this portion of the collections that forms the basis for the current research agenda. Three artefacts were dated within the framework of the research program *Dating of the Mesolithic and Neolithic of Eastern Europe: AMS dating for enhanced chronological resolution*, supported by the Wetland Archeology and Environments Research Centre at the University of Hull, England, whilst the fourth artefact was dated by Stuart *et al.* (2004; see below).

ARTEFACTS & AMS DATING

Unfortunately, as mentioned above, the Shigir collections lack stratigraphic context due to the recovery of finds during gold extraction activities. Despite this, the following text describes the detail of the artefacts that were dated during the current study, in terms of their form, and outlines the current interpretation of these

TABLE 1: AMS RADIOCARBON AGE ALONGSIDE CALIBRATED DATE (OXCAL V.4.2 & INTCAL13)

Artefact	*Sample*	*OxA*	*Determination* BP	*Calibrated date* BC (2σ)	$\delta^{13}C$
1	8975/1147	22282	9470 ± 45	9120–8630	–20.2
2	8985/1136	22283	8565 ± 45	7660–7530	–20.4
3	8979/659	20838	5000 ± 36	3940–3700	–20.6
4		11064	7990 ± 45	7060–6710	–19.7
	UR 56	X-2552-6*	8261 ± 37	7460–7170	–19.8

*Collagen from OxA-11064 reultra-filtered and dated (OxA-X-2552-6; see discussion of Artefact 4)

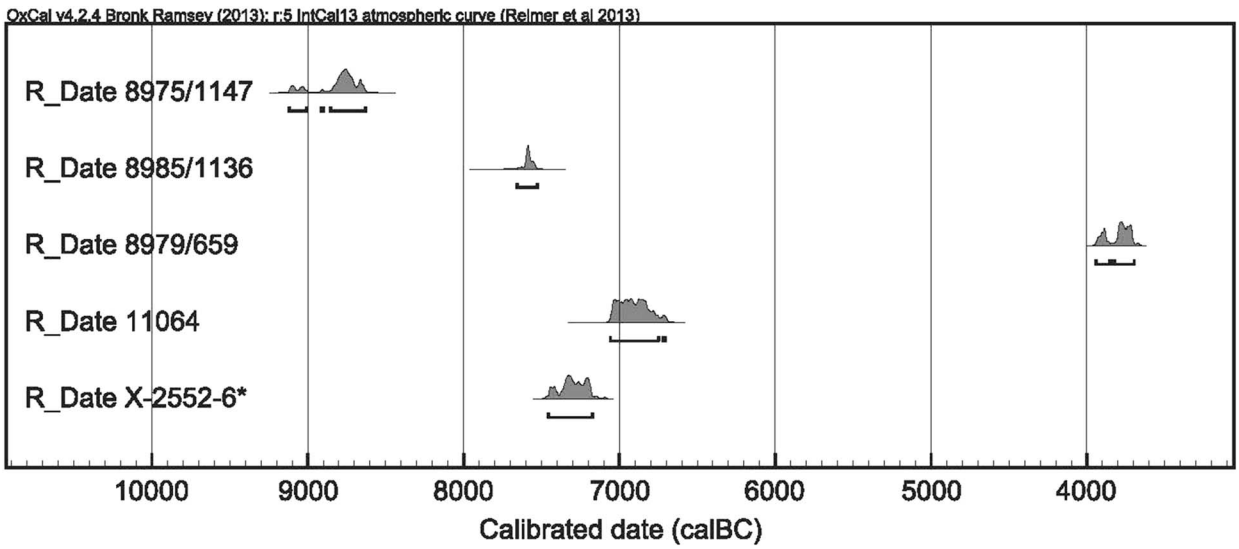

Fig. 2.
Multiplot of all AMS dates for Shigir artefacts in the current study

items in relation to existing chronological frameworks. The artefacts were chosen for analysis due to their (visual) good state of preservation and the lack of any evidence for conservation.

AMS dating was undertaken at the Oxford Radiocarbon Accelerator Unit (ORAU). In the routine pre-treatment of bone material for accelerator mass spectrometry (AMS) radiocarbon dating, the ORAU follows a procedure comprising a simple acid-base-acid (ABA) treatment followed by the revised gelatinisation and ultra-filtration (described in detail in Bronk Ramsey *et al*. 2004a; Brock *et al*. 2007, 187; 2010). Measurement was undertaken by AMS (Bronk Ramsey *et al*. 2004b). Table 1 displays the AMS radiocarbon determinations and calibrated date ranges and Figure 2 provides the distributions in a multi-plot for ease of reference. The online Appendix (Figs S1–S4) contains the probability distribution plots for each of the calibrated dates.

In the preparation of samples for analysis, it has been observed that the addition of the ultra-filtration stage in the processing is more successful at removing contaminants than the Longin (1971) method of collagen extraction (Brock *et al*. 2007, 187). However, despite this observation, the fourth item that we discuss below (Collection No. CM 8976 AIII-1007), which was originally dated to 7990 ± 45 BP (OxA-11064) by Stuart *et al*. (2004), is presented here in light of the identification of potential dating errors introduced by ultra-filtration (glycerol) problems at the Oxford AMS facility in 2000–2002. In that period AMS dates in the ranges OxA-9361–11851 and OxA-12214–12236 were producing results that were too old when inter-laboratory comparisons were made (Brock *et al*. 2007, also Bayliss *et al*. 2007, 21). We present new dating of this object (originally OxA-11064), and would like to thank colleagues at the ORAU for

undertaking this new analysis in time for its inclusion in the current paper.

Artefact 1. Collection No. CM 8975 AШ-1147: OxA-22282

This object is a composite needle-shaped arrowhead (Fig. 3) which can be considered transitional from massive needle-shaped arrowheads with a circular cross-section to flattened needle-shaped arrowheads. It has circular cross-section in the lower half and oval cross-section in the upper part. The tip of the point is broken from hitting some hard material. A long slot for inserts is grooved along one side. The inserts are not preserved. The cross-section of the slot is trapezoidal, 2 mm wide and 4 mm deep and it terminates in the middle of the base of the arrowhead. The base is conical and of medium length. The arrowhead was made from a splinter longitudinally cut from the diathysis of a long bone of a large mammal (most probably elk). The groove was made with a narrow burin sharpened by removing a narrow facet along its side, producing a characteristic cross-section. The surface of the arrowhead displays traces of fine longitudinal whittling, overlapped and partly removed by traces of fine longitudinal and transverse grinding on a fine grained stone, and later by polishing with hide or similar soft material. This object has been dated to 9470 ± 45 BP or 9120-8630 cal BC (Table 1). The probability distribution for this calibrated date, however, displays two distinct peaks, with a preference for a later date – eg, in reality the date is probably closer to 8630 cal BC than 9120 BC (Appendix Fig. S1).

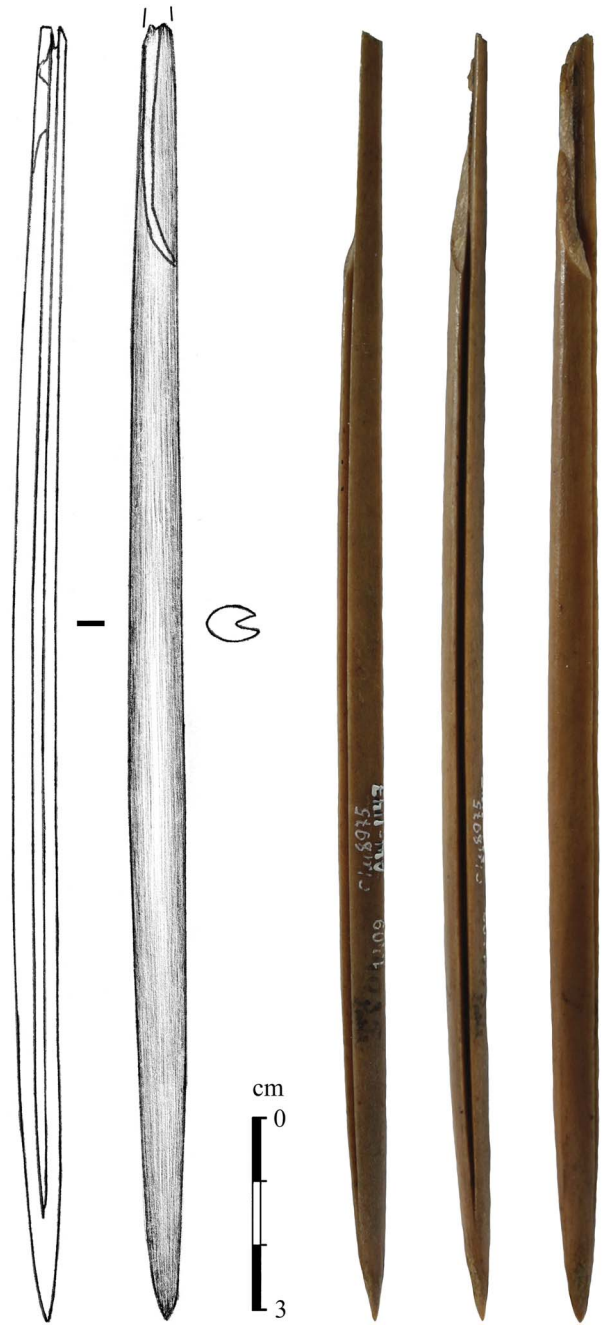

Fig. 3.
Artefact 1: slotted arrowhead from the Shigir collection (SOKM: drawing by M. Zhilin; photographed by E. Tamplon)

Artefact 2. Collection No. CM 8985 AШ-1136: OxA-22283

This large lance-head is made from a mammalian long bone, longitudinally cut into two halves (Fig. 4). The point is preserved while the basal part is broken off. The cross-section (except at the point) preserves the natural cross-section of the bone itself. The point is conical and slightly oblique, treated by longitudinal whittling and scraping. The tip is flattened by polishing with a fine grained abrasive slab at an angle about 45° to the artefact axis. The diameter of the flat tip is 3 mm. Analogous production methods for lance-heads of comparable form have been observed on a series of artefacts from Mesolithic sites in Eastern Europe (eg, Zhilin 2001a, 107). When the point started to crack, as a result of hitting hard materials, this form of polishing appears to have prevented further damage. The tip of the point is rounded, smoothed, and slightly crushed.

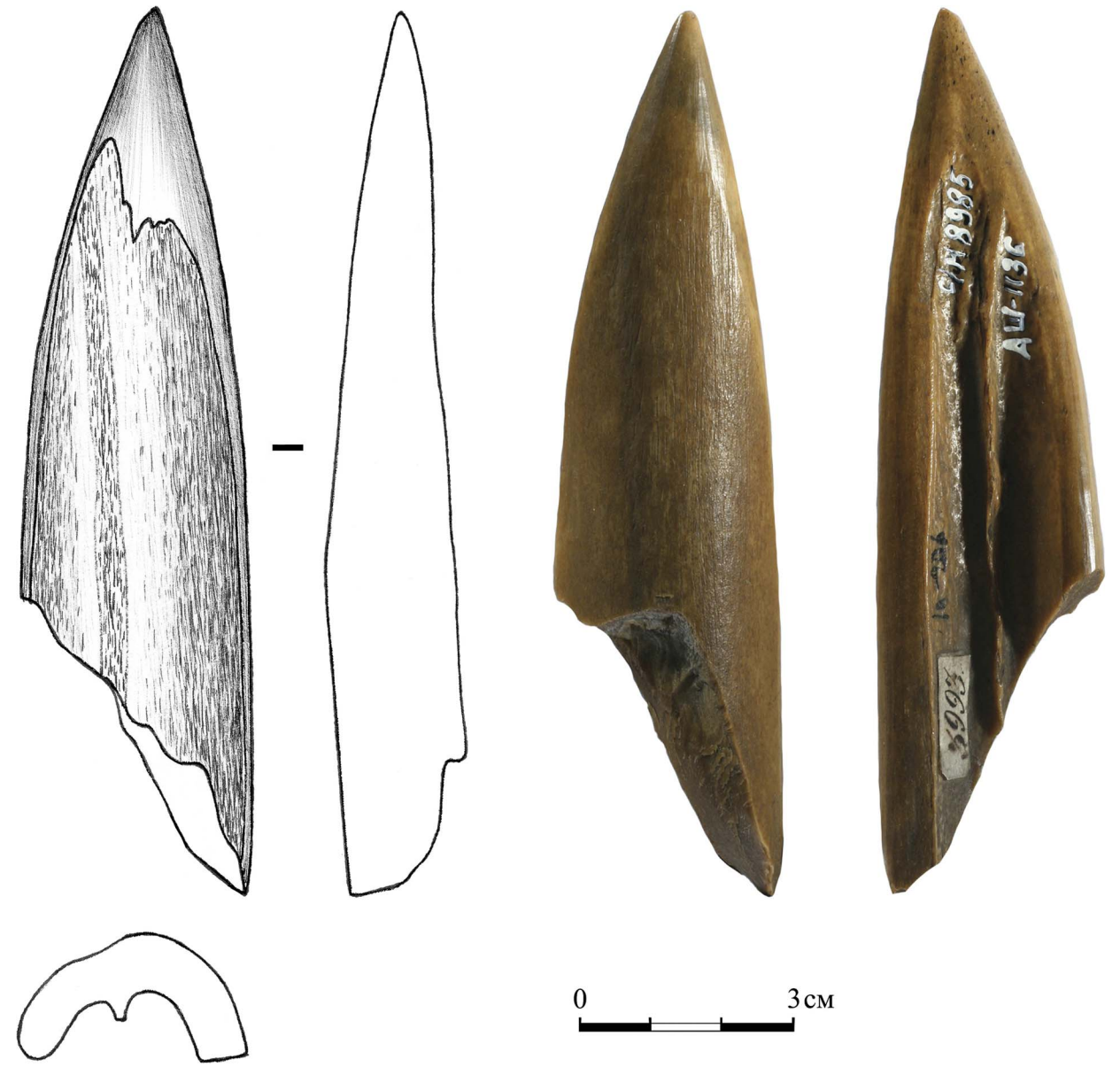

Fig. 4.
Artefact 2: fragment of lance-head from the Shigir collection (SOKM: drawing by M. Zhilin; Photographed by E. Tamplon)

The heavy polishing at the tip of the point quickly lessens away from the tip. Thin scratches, running from the tip along the tool axis, are observed within the area of polishing. By comparison with experimental work on a range of artefacts, it appears that similar traces of use-wear indicate multiple piercing of some soft, slightly dirty, material. This object has been dated to 8565 ± 45 BP; 7660–7530 cal BC (Table 1 & Appendix Fig. S2).

Artefact 3. Collection No. CM 8979 АШ-659: OxA-20838

This barbed, unilateral point with small, sparse 'beak-shaped' barbs in the upper part is 207 mm in surviving length (Fig. 5). Only the middle part of the artefact is preserved, as the point and basal parts are broken off. The cross-section of the stem with a barb is pear-shaped. The base is long and conical, with a triangular

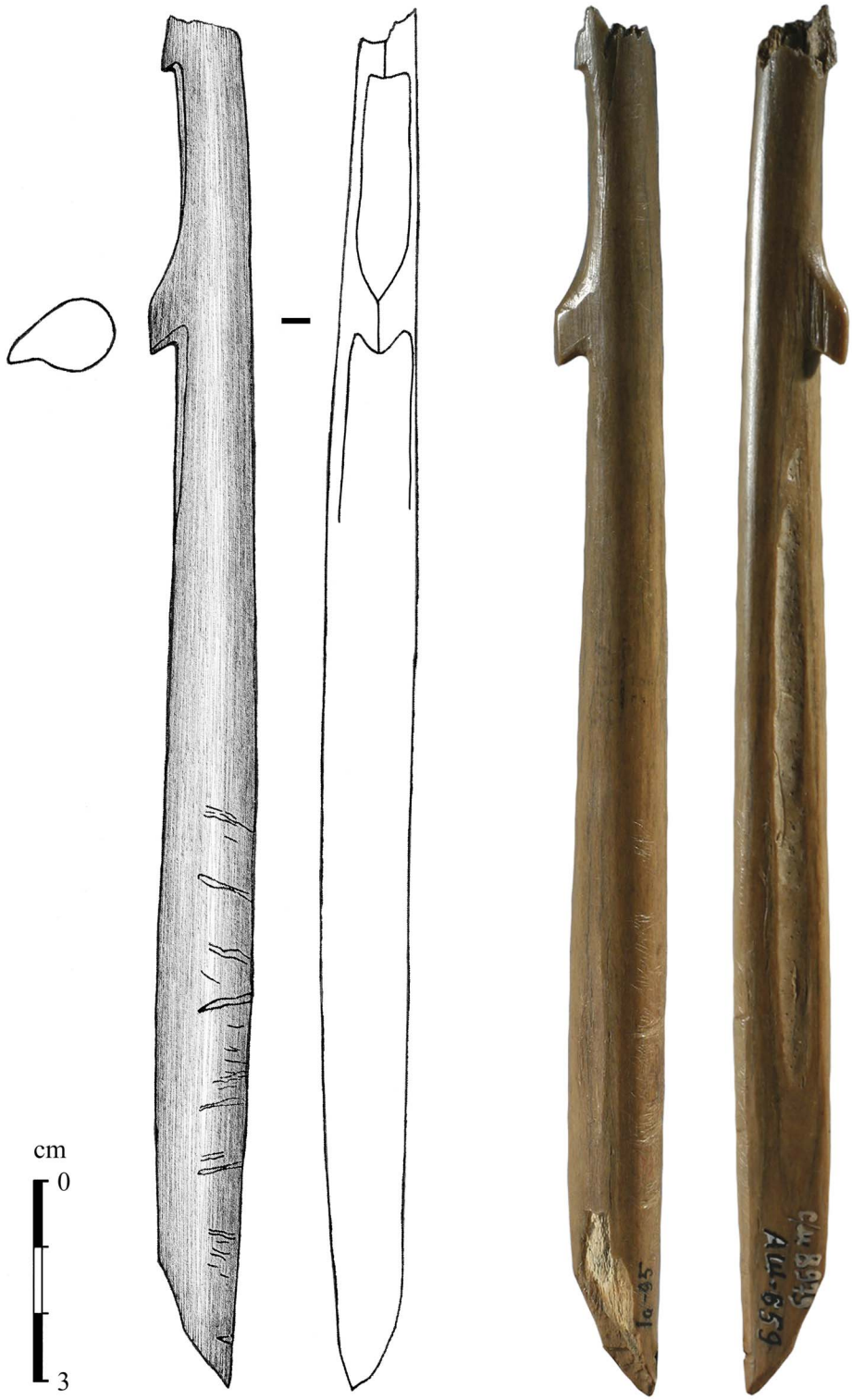

Fig. 5.
Artefact 3: fragment of a barbed point from the Shigir collection (SOKM: drawing by M. Zhilin; photographed by E. Tamplon)

cross-section with rounded angles. The artefact is made from a blank detached from the side of a long bone (possibly deer, but probably elk) with a natural longitudinal rib. Traces of longitudinal whittling are observable on the surface. The bases of the barbs are transversally sawn and they were shaped by whittling and scraping. Transverse incisions were haphazardly sawn at the butt of the basal part, probably to aid hafting. Traces of careful final treatment, as indicated by oblique and transversal grinding, probably produced using a fine grained slab, and light polishing are observable on the stem and barbs. This object has been dated to 5000 ± 36 BP; 3940–3700 cal BC (Table 1). The probability distribution for this calibrated date is problematic, however, as it displays two clear major distribution peaks for the radiocarbon age (Appendix, Fig. S3) and, as such, the calibrated date produced has to be interpreted with some caution.

Artefact 4. Collection No. CM 8976 AIII-1007: OxA-11064 & OxA-X-2552-6

This dagger is made from the antler of a giant deer (elk) (*Megaloceros giganteus* Blum.). It is asymmetric and very large (*c.* 350 mm in surviving length), with blunt sides and a sharp pointed end (Fig. 6). The handle is not pronounced and the cross-section is flat–convex. The artefact was made by splitting the flat part of the antler. The pre-form was cut with a burin and the edges treated by longitudinal whittling. The butt end displays traces of chopping with a stone adze. The soft tissue from the ventral (internal) side was removed and this side was made flat by grinding. Traces of final treatment by fine grinding and polishing are preserved on the surface. The handle part, up to the middle of the dagger, displays dark transversal stripes perhaps indicative of traces relating to binding with leather, birch bark, or something similar.

As noted above, the original age for this sample was recorded as 7990 ± 45 BP (OxA-11064), which would calibrate to 7060–6710 cal BC (Table 1). Originally, Stuart *et al.* (2004, 688) argued that none of their dated samples was of low enough pre-treatment yield to be affected by the ultra-filtration contamination. As such OxA-11064 was not subjected to any re-analysis or inter-laboratory testing for accuracy and was not withdrawn. In light of subsequent discussions of AMS dates within the contaminated ranges (even those with high collagen yields) that have been shown to be in error (Bayliss *et al.* 2007, 21, Meiklejohn *et al.* 2011, 38), colleagues at the ORAU(NRCF) re-ran the sample as a test for accuracy (Appendix Fig. S4 & Fig. 2).

Interestingly, despite the discrepancies noted by Meiklejohn *et al.* (2011, 30 & 32), and variability in the offsets of the dates as a result of the contamination (Brock *et al.* 2007, 188) the new determination obtained on artefact 4, at 8261 ± 37 BP (OxA-X-2552-6) is actually older than the original determination of 7990 ± 45 BP (OxA-11064). This is counter to the expected result which, if contaminated with glycerol, should have produced a younger radiocarbon age. Correspondence with T. Higham (pers. comm) has led to the suggestion that the sample is not homogeneous – usually the result of conservation techniques undertaken at museums – but there is no evidence for this from the sample or museum records. The collagen yields for both samples were within acceptable parameters: 5.6‰ for OxA-11064 (bone) and 15 < ‰ for OxA-X-2552-6 (from collagen).

The C:N ratios and the $\delta^{13}C$ (used as measures for quality control at ORAU) for the two dates are interesting – the samples have the exact same C:N ratio of 3.53, which is surprisingly consistent. The ORAU have recently updated their C:N protocol, and now 3.45 is the higher boundary, which would now suggest (based on C:N) that *both* the dates produced are unreliable – and certainly would fail quality control checks if they were processed in 2015. The triplicate $\delta^{13}C$ values for OxA-11064 and OxA-X-2552-6 are –19.7‰ and –19.8‰ respectively (Higham pers. comm.); this again is very similar – particularly as the machine error is ±0.2‰. The similarities in the C:N ratios and the $\delta^{13}C$ values do not support the possibility of contamination (eg, museum conservation) – if significant differences were observed it would be possible to identify confidently some source of contamination. But, equally (and importantly), the absence of differences between the C:N ratios and the $\delta^{13}C$ values do not wholly disprove the possibility of contamination either.

Overall, while the new date (OxA-X-2552-6) remains commensurate with a later Mesolithic age for this artefact, the calibrated ranges do not overlap at 2σ (Table 1), which is somewhat perplexing as the dating process and analytical parameters remain consistent (Higham pers. comm.). As no conservation has been undertaken on this object, and the object itself is visually homogeneous (Kosintsev pers. comm.), the reasons for the earlier age produced by the re-analysis

Fig. 6.
Artefact 4: antler dagger from the Shigir collection (SOKM: drawing by M. Zhilin; photographed by E. Tamplon)

remain to be determined. The probability distribution for the date (OxA-X-2552-6, Appendix Fig. S4b) demonstrates a large range but the peak is mostly homogeneous in its distribution. This sample would benefit from being entirely reprocessed at ORAU (from bone, not from collagen), in an attempt to identify the source of the problem. The new age range for artefact 4 is calibrated at 7460–7170 cal BC, and the date itself is some 270 radiocarbon years older than OxA-11064 (see Fig. 2 and Appendix Fig. S4).

DISCUSSION

Despite the fact that the dating of the Shigir Idol, and comparisons of artefact types from the Shigir collections with artefacts from other sites in eastern Europe, point to an early (ie, Mesolithic) date for some the objects housed in the SOKM in Yekaterinburg, until the current programme only the Shigir Idol had been the subject of absolute dating. The new dates, presented above, allow us to provide some important resolution to the materials in the Shigir collections. In general the results indicate that we have three objects that date to all periods of the Mesolithic, and also one object which is placed in the later Neolithic.

Artefact 1 (Fig. 3) is a composite needle-shaped arrowhead. In general, large needle-shaped arrowheads, with either a circular or flattened cross-section and a single long slot, are identified in both the terminal Palaeolithic and the Mesolithic of the forest zone of Eurasia. Arrowheads of this form from Mesolithic sites in Eastern Europe are generally dated by pollen and radiocarbon analysis to either the pre-Boreal – for instance at the site of Ivanovskoye 7 (Layer IV) or Stanovoye 4 (Trench 3, Layer III) – and/or the Boreal period – as at the sites of Stanovoye 4 (Trench 2, Layer III; Zhilin 2001a; Zhilin *et al.* 2002) and Veretye 1 (Oshibkina 1997). An arrowhead of this type also comes from Kunda Lammasmagi in Estonia (Indreko 1948), and fragments of two more arrowheads have been identified in the Boreal layer of Zveinijeki 2 (Zagorska & Zagorskis 1989, 419) in Latvia. The collection of stray finds from the Lubana Lake in Latvia also contains similar arrowheads with a conical base (Vankina 1999).

In the Urals area, large needle-shaped arrowheads with circular and flattened cross-sections and a single long slot, have been recovered from the Mesolithic horizon of the Lobvinskaya cave site, which is dated to the late pre-Boreal–early Boreal periods by pollen analysis, and to 9265 ± 255 BP (IERZh-92) by radiocarbon. Another example comes from the Mesolithic layer at Shaitanskaya cave, which Chairkin and Zhilin (2005, 259–69) consider to be even earlier than the Mesolithic layer at Lobvinskaya cave. Fragments of similar arrowheads have been recovered from the basal layer of a trench, which contained Mesolithic arrowheads, at the foot of the rock within the Kamen Dyrovatyi cave (Serikov 2000). The dating of Artefact 1 to 9470 ± 45 BP (OxA-22282), calibrated to 9120–8630 cal BC (Table 1), technically overlaps with the 2σ range for Lobvinskaya cave, which spans 9255–7826 cal BC but the large error margin of this sample (255 years) makes it questionable how useful this date is in refining the chronological sequence. The Shigir arrowhead is placed securely within the earlier Mesolithic period (middle of the pre-Boreal) by the current dating and, importantly, a number of similar artefacts are preserved in the collections at SOKM.

Artefact 2, the lance-head (Fig. 4), has multiple analogies to Mesolithic sites of the forest zone of Eastern Europe. The earliest finds come from the basal layer (Layer IV) of Stanovoye 4, dated to the Pleistocene–Holocene transition. These objects are also found at sites dated to the pre-Boreal period, for instance, Pully in Estonia and layer III in trench 3 of Stanovoye 4, and the basal layer (Layer IV) at Ivanovskoye 7 on the Upper Volga (Zhilin 2001a; Zhilin *et al.* 2002). These objects mainly appear to date to the Boreal period: Kunda Lammasmagi (Indreko 1948) and Zveinieki 2, middle layer (Zagorska & Zagorskis 1989) in the Eastern Baltic area; Veretye 1 and Sukhoye (Oshibkina 1997; 2006) in the Eastern Onega Lake area; and Stanovoye 1 (Averin *et al.* 2006), Stanovoye 4, and Ozerki 16 & 17 (Zhilin 2001a; 2006) in the Upper Volga area. There are, however, a smaller number of finds that are dated to the later Mesolithic, for instance, in the middle and late Mesolithic layers of Zvidze (Loze 1988) and Osa in Latvia, and layer IIa of Ivanovskoye 7 in the Upper Volga area (Zhilin *et al.* 2002). Furthermore, these objects have been identified at Neolithic sites such as Sharnale in Lithuania (Butrimas 1996) and in burial no. 3 at the site of Ksizovo in the Middle Don area (Smolyaninov & Bessudnov 2009). The calibrated age of the lance- head from Shigir, at 7660–7530 cal BC (Table 1) securely places the age of this object in the middle of the Boreal period, ie, the middle Mesolithic.

Whilst there are a number of similar artefacts in the Shigir collections it is worth noting that, in the Urals region, two fragments of lance-heads have also been recovered from the Mesolithic horizon at the site of Koksharovsko-Yurjinskaya II (Serikov 2000). At this location radiocarbon dating of a fragment of a flat slotted arrowhead (8635 ± 40 BP; KIA-42078/2; 7670–7590 cal BC), and of glue from the slot of this arrowhead (8520 ± 35 BP; KIA-42078/1; 7730–7585 cal BC), indicate occupation of the site during the middle of the Boreal period. To date, most analogies to this lance-head, including those from the Urals area, all come from Boreal period sites which, as the new dating has shown, corresponds with the date of the Shigir lance-head.

Artefact 3 is a long barbed point (Fig. 5). Various modifications of large, long barbed points, which were used as javelin and leister heads, are known in the Mesolithic and Neolithic of the forest zone of northern Eurasia. Points with sparse beak-shaped barbs in the upper part of the stem and a long base have been recorded at a number of East European sites, for instance in the Volga Basin early Mesolithic at Ivanovskoye 7 (Zhilin *et al.* 2002); at the middle Mesolithic site of Veretye 1 in the easten Baltic (Oshibkina 1997); and at the late Mesolithic Volga Basin sites of Okayomovo 4 and 5, and Nushpoli 18 (Zhilin 2001a); Ivanovskoye 7 and Ozerki 5 (Zhilin *et al.* 2002; Zhilin 2006). Star Carr in England has also produced other types of barbed points, some of which were made from red deer bone and antler, which have small sparse barbs in the upper part of the stem (Clark 1954). In general, these analogies give broad earlier chronological limits for these points. Importantly, similar artefacts have been identified at the Neolithic site of Repische, Msta culture (Zimina 1996), and a series of comparable barbed points have also been identified in the Lubana collection in Latvia, which incorporates both Mesolithic and Neolithic stray finds (Vankina 1999). In the Urals area long barbed points have only been identified in the Shigir collection.

On the basis of the new date obtained for Artefact 3 the calibrated range indicates the existence of these objects in the Urals area during the latest Neolithic period at 3940–3700 cal BC (Table 1), which corresponds to the second half of the Atlantic period. As such, the Late Neolithic date of this barbed point not only indicates a long history of use for this artefact type in the Trans-Urals region, but it also suggests that typological dating based on analogies with objects of a similar form is inadequate for providing a reliable chronological age for these objects, given this extended functional lifespan.

The final item that is considered here has been dated previously (Stuart *et al.* 2004), but it has been included as part of the current study due to the possibility of ultra-filtration issues and subsequent redating (discussed above). Artefact 4 (Fig. 6) is a dagger made from the antler of a giant deer. This object has no analogies among excavated sites in Eastern Europe, but the part of the Shigir collection that is housed in the State Hermitage museum includes two fragments of points from similar artefacts, which are most probably also made from giant deer antler. As noted above, there were possible issues with the original dating of this object at 7990 ± 45 BP (OxA-11064) but, even allowing for an exaggerated 300 year over-aging error, this object is still placed at 2σ to 7460–7170 cal BC, which corresponds to a later Mesolithic age for this object, just at the start of the Boreal–Atlantic transition.

CONCLUSIONS

As noted in the earlier parts of this paper, there is a considerable degree of imprecision in the typological seriation of bone industries throughout Europe. In general, while broad age categories of Mesolithic, Neolithic, etc, or subdivision into earlier and late Mesolithic, etc, are attempted, the current study has shown that these schemes are imprecise and fail to account for palimpsests of activity and the fact that certain objects can be shown to have extremely long use histories, which can extend across distinct chronological periods.

The new AMS dates presented here not only add resolution to the chronology of the Trans-Urals region but they also highlight the fact that the duration of artefact use in this region is considerable. The dates also highlight the fact that the human–landscape interactions at Shigir encompasses a significant amount of the earlier Holocene, suggesting that these locations had considerable value to prehistoric groups in terms of the resources that they would have provided. Importantly, the new dating also enhances the chronological position of finds from the Shigir collections, while also confirming that this assemblage contains finds from these different periods. The new dating has confirmed that, as with the Gorbunovo peat bog, Shigir was already a focus for settlement and

hunting activities during the early Mesolithic period; as indicated by the date of the slotted arrowhead. Settlement continued through into the middle Mesolithic, as shown by the date of the lance-head, and extended into the late Mesolithic, documented by the date of the dagger made from giant deer antler. These results confirm that settlement in the Middle Urals area occurred throughout the Mesolithic period (Zhilin & Savchenko 2010a; 2010b) and not only during its later phase, as was originally thought (Serikov 2000).

On the basis of recent multidisciplinary investigations of sites in the Middle Eastern Urals area some aspects of the Mesolithic bone artefact chronology can now be determined with a measure of reliability, even when making typological comparisons. However, at the same time, the current study has shown that while artefacts such as long barbed points (Artefact 3) have their genesis in the earlier Mesolithic, for instance, at sites such as Ivanovskoye 7 in the Volga Basin, with parallels to Star Carr in the Vale of Pickering, England, the Shigir point is of latest Neolithic age, thus reinforcing the observation that certain artefact forms have a long tradition of use. This observation is of considerable importance as the duration of use for this object suggests that, in the absence of direct dating, this object could have been incorrectly attributed a Mesolithic age for its use.

The composite needle-shaped arrowhead (Artefact 1) has been confirmed as an earlier Mesolithic piece, which is commensurate with the dating of these objects in eastern Siberia through to the eastern Baltic region (Vdovin & Makarov 1996; Zhilin 2001a; Zagorska & Zagorskis 1989). The lance-head (Artefact 2), has been shown to date to the mid-Boreal period at 7660–7530 cal BC which, again, accords well with the chronological position indicated by typological comparisons to other sites in Eastern Europe, although this artefact form is not in evidence during the Mesolithic period in Siberia. The final artefact considered in this study, the dagger, is currently unique in that, to date, artefacts of this form in the Urals region only exist in the Shigir collections. The later Mesolithic age that has been assigned to this artefact indicates that we should perhaps consider AMS dating of the items housed in the Hermitage in order to confirm this chronological position further.

It is important to note that while the dating of Artefacts 1 and 2 suggests that typological comparisons are valid for at least some of the artefacts in the Shigir collections, the use of the typological method for determining the chronological limits of these finds often results in a generic, and long duration of use being suggested. Furthermore, the Neolithic and Bronze Age bone industry in the Urals area remains relatively understudied (Chairkina 2011; Zhilin & Savchenko 2010a) and, as such, it is anticipated that in future studies we will seek to apply new AMS dating to artefacts from the Shigir collections; particularly those that appear to be later on typological grounds, in order to define the chronological limits of the bone industry. Once this new work is undertaken the Shigir collection will, no doubt, provide an important and more reliable source for future research.

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SUPPLEMENTARY MATERIAL

Fig. S1. Artefact 1: Probability plot for OxA-22282
Fig. S2. Artefact 2: Probability plot for OxA-22283
Fig. S3. Artefact 3: Probability plot for OxA-20838
Fig. S4. Artefact 4: Probability plots for a. OxA-11064; b. OxA-X-2552-6.

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RÉSUMÉ

Nouvelles datations S.M.A,d'armes en os et bois de cerf des collections de Shigir conservées au musée régional de Sverdlovsk, Oural, Russie, de Svetlana Savchenko, Malcolm Lillie, Mikhail, G. Zhilin et Chelsea E. Budd

Cet article présente de nouvelles datations S.M.A. de trouvailles organiques de la tourbière deShigir (Shigirsky) située dans la province de Sverdlovsk, district de Kirovgrad dans l'Oural. La tourbière se trouve immédiatement au sud de la rivière Severnaya Shuraly, avec les monts Oural à l'ouest. Des prospections et des excavations intermittentes ont été entreprises à cet endroit à partir de 1879, le résultat en a été la récupération de plus de 3000 objets façonnés culturels, y compris des rames, des sculptures d'oiseaux, des figurines en forme de serpent, des skis en bois, des pointes de flèche et des hameçons. Les dates que nous présentons ici indiquent que non seulement l'utilisation humaine des marais de Shirgir fut de longue durée mais les formes des objets manufacturés semblent aussi avoir eu une considérable durée d'utilisation tout au long des périodes de la première partie de la préhistoire prises en considération ici.

ZUSSAMENFASSUNG

Neue AMS-Datierungen von Waffen aus Knochen und Geweih aus den Shigir Sammlungen des Sverdlovsk Regionalmuseums, Ural, Russland, von Svetlana Savchenko, Malcolm Lillie, Mikhail G. Zhilin und Chelsea E. Budd

Dieser Beitrag stellt neue AMS-Datierungen organischer Funde aus dem Shigir-Moor vor, das in der Provinz Sverdlovsk im Kirovgrad-Distrikt des Urals gelegen ist. Das Torfmoor liegt unmittelbar südlich des Flusses Severnaya Shuraly, mit dem Ural im Westen. Zeitweilige Surveys und Ausgrabungen wurden an diesem Fundplatz seit 1879 durchgeführt, was zur Entdeckung von mehr als 3000 Artefakten führte, darunter Ruder, Vogelskulpturen, Schlangenfigurinen, hölzerne Skier, Pfeilspitzen und Fischhaken. Die hier vorgelegten Daten zeigen, dass wir es nicht nur mit einer langen Dauer menschlicher Nutzung der Feuchtgebiete von Shigir zu tun haben, sondern dass auch die Formen der Artefakte einer signifikanten Gebrauchsdauer während der frühen prähistorischen Epochen, die hier diskutiert werden, zu unterliegen scheinen

RESUMEN

Nuevas dataciones radiocarbónicas por AMS de armas de hueso y asta de las colecciones de Shigir albergadas en el museo regional Sverdlovsk, Urales, Rusia, por Svetlana Savchenko, Malcolm Lillie, Mikhail, G. Zhilin y Chelsea E. Budd

Este artículo presenta las nuevas dataciones radiocarbónicas por AMS obtenidas de los restos orgánicos procedentes de la turbera Shigir (Shigirsky), ubicada en la provincia de Sverdlovsk, distrito Kirovgrad de los

Urales. El pantano está localizado inmediatamente al sur del río Severnaya Shuraly, con los Urales al oeste. Desde el año 1879 se han estado desarrollando prospecciones y excavaciones de manera intermitente, provocando el descubrimiento de más de 3000 artefactos culturales, incluyendo remos, esculturas de pájaros, figuras de serpientes, esquíes de madera, puntas de flecha y anzuelos de pesca. Las dataciones presentadas en este artículo no sólo reflejan una ocupación humana de larga duración en los humedales de Shigir, sino que también manifiestan un uso prolongado de los artefactos durante los primeros periodos prehistóricos considerados aquí.