

University of Groningen

## Bronze Age Wool Textile of the Northern Eurasia

Shishlina, N. I.; Orfinskaya, O. V.; Hommel, P.; Zazovskaya, E. P.; Ankusheva, P. S.; van der Plicht, J.

*Published in:*  
 Nanotechnologies in Russia

*DOI:*  
[10.1134/S1995078020050146](https://doi.org/10.1134/S1995078020050146)

**IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.**

*Document Version*  
 Publisher's PDF, also known as Version of record

*Publication date:*  
 2020

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Shishlina, N. I., Orfinskaya, O. V., Hommel, P., Zazovskaya, E. P., Ankusheva, P. S., & van der Plicht, J. (2020). Bronze Age Wool Textile of the Northern Eurasia: New Radiocarbon Data. *Nanotechnologies in Russia*, 15(9-10), 629-638. <https://doi.org/10.1134/S1995078020050146>

### Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

### Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

*Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.*

---

---

NATURAL SCIENTIFIC METHODS IN STUDYING  
CULTURAL HERITAGE SITES

---

---

## Bronze Age Wool Textile of the Northern Eurasia: New Radiocarbon Data

N. I. Shishlina<sup>a,\*</sup>, O. V. Orfinskaya<sup>b</sup>, P. Hommel<sup>c</sup>, E. P. Zazovskaya<sup>d</sup>,  
P. S. Ankusheva<sup>e,f</sup>, and J. van der Plicht<sup>g</sup>

<sup>a</sup> State Historical Museum, Moscow, Russia

<sup>b</sup> Centre of Egyptological Investigation, RAS, Moscow, Russia

<sup>c</sup> Department of Archaeology, Classics and Egyptology, University of Liverpool, Liverpool, United Kingdom

<sup>d</sup> Institute of Geography, RAS, Moscow, Russia

<sup>e</sup> South Ural State Humanitarian Pedagogical University, Chelyabinsk, Russia

<sup>f</sup> Institute of Mineralogy SU FRC MG UB RAS, Miass, Russia

<sup>g</sup> Groningen University, Groningen, The Netherlands

\*e-mail: nshishlina@mail.ru

Received August 11, 2020; revised August 11, 2020; accepted August 26, 2020

**Abstract**—The Bronze Age of northern Eurasia is characterised by major socio-economic changes. A secondary products revolution defined an overall trajectory in these global economic transformations. Innovative changes in fibre technologies led to the appearance of woven wool textiles and the production and consumption of new types of garment. Analysis of the first direct AMS <sup>14</sup>C dates from woven wool fibres from Bronze Age sites across northern Eurasia allow us to define key stages in the directional spread of woven wool textiles and to determine the cultural context of this process of technological transmission.

DOI: 10.1134/S1995078020050146

### INTRODUCTION

Introduction of wool production in Prehistoric societies has been studied by many scholars [1–6]. Unfortunately, woollen textiles are often poorly preserved in the archaeological record and, as a result, the reconstruction of woollen textile production across different periods of Prehistory is largely reliant on the study of indirect evidence such as imprints, weaving tools, written sources, non-pollen palynomorphs and the zooarchaeological analyses of animal bones [2, 3, 5, 7–13].

The earliest archaeological evidence of wool textiles in northern Eurasia—a fragment of cloth found in the later Maykop culture dolmen burial at Tsarskaya—can be dated around 4000 calBC. However, because it was made from a mix of wool and cotton yarns, this fabric was likely imported from the South. This conclusion is also supported by evidence for the use of tannin-based dyes, which were unknown at this time in the Caucasus [14].

At present, the almost complete lack of direct radiocarbon dates of preserved wool samples—and in the absence of other datable material from the same contexts—makes it difficult to present a clear picture of the cultural-chronological associations of this material. In the main regions of northern Eurasia where

woolly-fleeced sheep/goats appeared in the Bronze Age (eastern Europe, the Urals, Siberia, and Kazakhstan) the process behind the emergence and transformation of this novel textile technology remains unclear.

Thus far, only the fragment, described above, from Dolmen no. 2 at Tsarskaya in the northern Caucasus [15] and another from the site of Stepnoye VIII in the Ural Region [16] have been directly radiocarbon dated.

The aim of this project was to conduct a new programme of radiocarbon dating, focussed on the earliest surviving samples of woven wool textiles (or directly associated carbon-rich materials) from the Eurasian Bronze Age, from the Caucasus to Siberia. Based on a statistical analysis of these data—Bayesian modelling—we were able to resolve the chronological and spatial components of the data to investigate the spread of woollen fibre through this vast study region.

### METHODS AND SAMPLES

Fifty-two fragments from Bronze Age 26 sites located in the Caucasus, steppe and forest-steppe eastern Europe, the Ural region, Kazakhstan, and Siberia were sampled for the analysis (Fig. 1). According to the technological analyses, these samples were



**Fig. 1.** (Color online) Bronze Age burial grounds with remains of woollen and cotton textiles. 1—Tsarskaya (Novosvobodnaya); 2—Bedeni; 3—Shakhaevsky I; 4—Yergueni; 5—Bugurusta; 6—Aleksesvsky II; 7—Zolotaya Niva II; 8—Gerasimovsky III; 9—Gerasimovsky II; 10—Aleksesvsky; 11—Tavlykaevsky II; 12—Chernyaki II; 13—Agapovka II; 14—Stepnoye VII; 15—Alakul; 16—Ushkattinsky I; 17—Tundyk; 18—Kairan I; 19—Berezovy Rog; 20—Borisoglebovsky I; 21—Ust'-Yerba; 22—Uzhur; 23—Uibat; 24—Bestamak; 25—Dzhangildy-5; 26—Lisakovsky; 27—Shahr-i-Sokhta; 28—Arslantepe; 29—Bogolubovka; 30—Girsu; 31—Ur; 32—Ananauri; 33—Dhuweila; 34—Gumugou; 35—Xiaohe; 36—Keliyahe.

divided into several groups: fragments of non-plied and plied yarn, cords, plaited braids, and woven cloth and so forth (Fig. 2). Some of these technological results are published [17–21], the rest are currently being prepared for publication.

To explore the transmission of wool textile across northern Eurasia, we obtained direct AMS  $^{14}\text{C}$  measurements on 16 wool samples (fibres from woven textiles) from well-defined cultural contexts in order to establish their absolute age. Before sampling, the conservation history of the fragments was studied in as much detail as possible. The fragments were also examined under the microscope for evidence of unreported conservation, to exclude textiles which has been subjected to restoration. Radiocarbon data obtained were calibrated with the OxCal 4.3 program [22], using the calibration curve IntCal13 [23].

All dates with reported instrumental error  $>70$  radiocarbon years were rejected from our dataset. The second phase was to exclude samples which showed a substantial offset from the expected C/N values for keratin. However, C/N ratios were not always reported in the legacy data and were not available from all laboratories even for new samples.

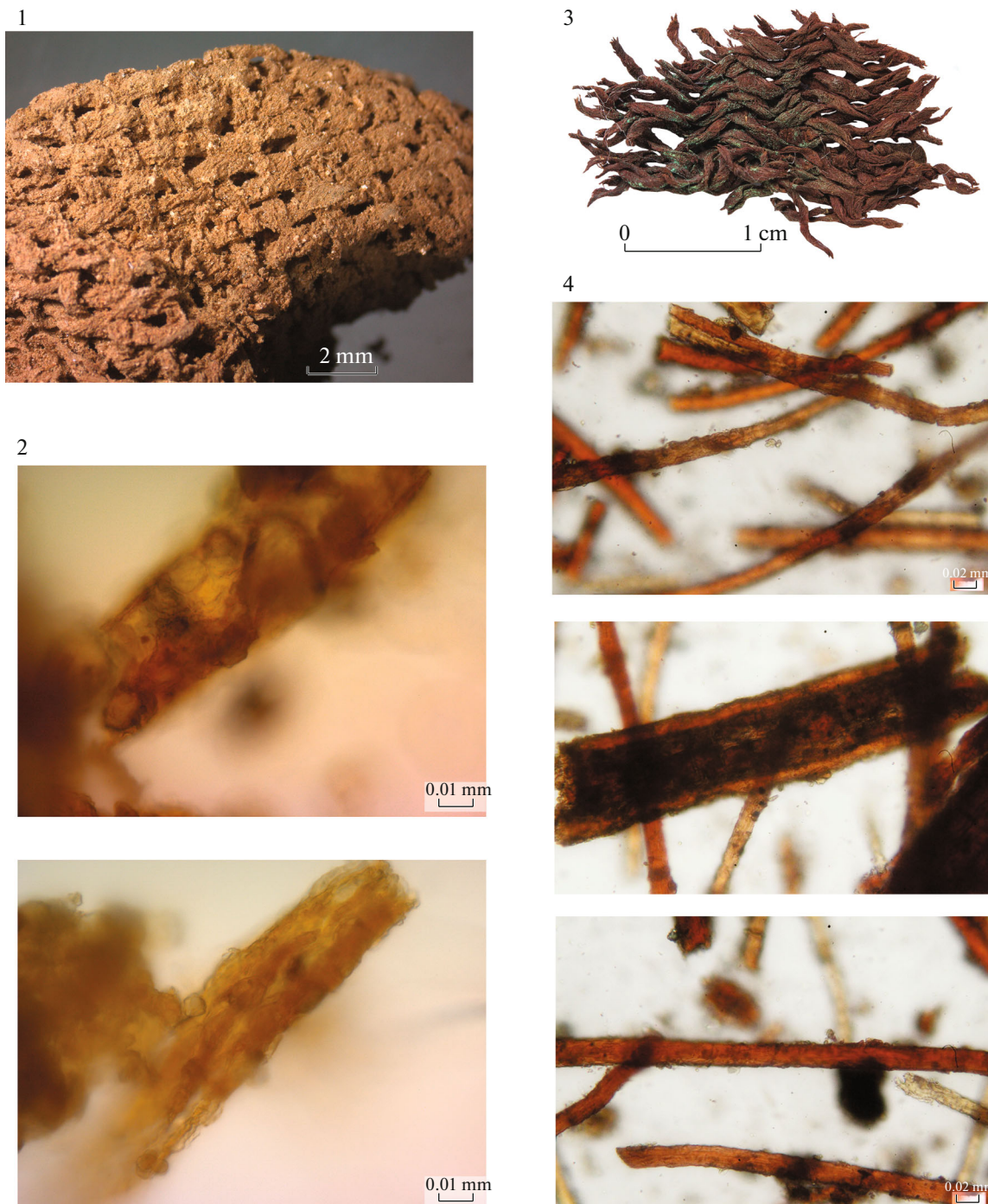
Wherever possible, a detailed cross-comparison between the textile samples and the associated radiocarbon dates on other materials was carried out to verify our results. Existing data were supplemented by

new AMS  $^{14}\text{C}$  measurements on other datable materials from the same archaeological contexts: wood (6), nuts/seeds (2), leather (1), and animal bone (1). The results confirmed that samples showing minor C/N offsets were found to be consistent with other materials in the graves. Similar findings have also been reported elsewhere [24]. Larger shifts in C/N ratios for woollen textile samples always showed a substantial negative offset between their radiocarbon age and the radiocarbon age of other associated datable materials samples.

To minimize the effects of any uncertainty about the validity of these dates, all textile dates were treated as *terminus post quem* dates employing the *Outlier\_model* [22] command in OxCal 4.3 with the following model parameters—(Exp(1,–10,0),  $U(0,3)$ ,  $t$ ) and  $p = 1$ —using assumptions that are often used to model dates made on wood and charcoal fragments. Other forms of short-lived material were included with standard assumptions—( $T(5)$ ,  $U(0,4)$ ,  $t$ ) and  $p = 0.05$ .

These steps, while far from a perfect solution, represent a reasonable compromise in the combination of data from multiple sources into a single analytical study. Future research will enable us to test the robustness of these decisions.

Using OxCal 4.3, the new  $^{14}\text{C}$  data were combined into a single Bayesian model with a wider set of previously published AMS  $^{14}\text{C}$  dates on textiles and associ-

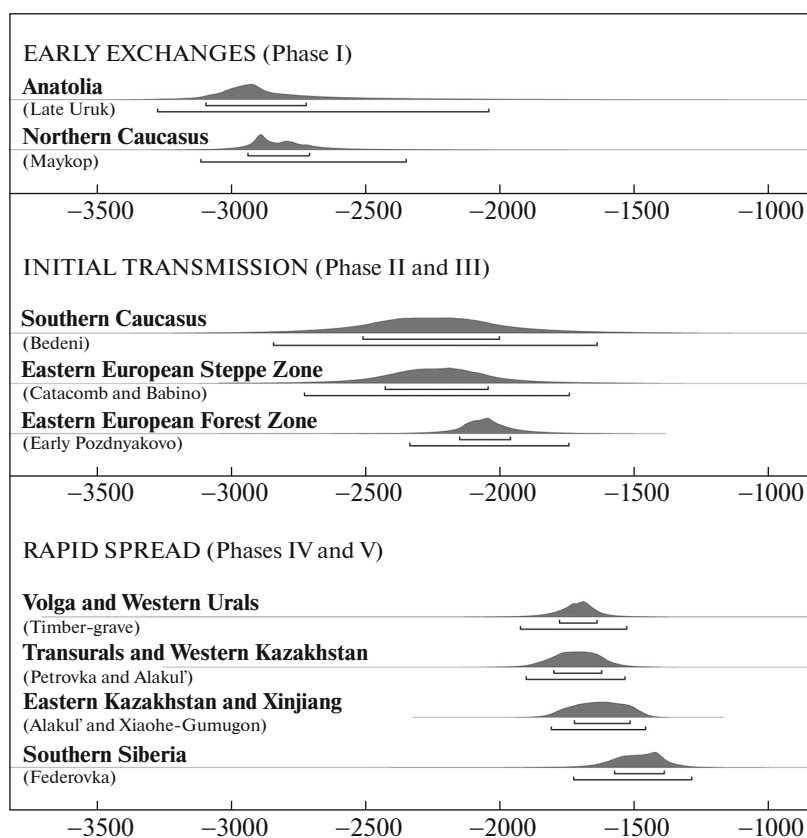


**Fig. 2.** (Color online) Fragments of wool textiles. Yergueni, kurgan 6, grave 3, Catacomb culture: 1—textile sample, 2—photomicrographs of wool fibres; Ust-Yerba, grave 1, Federovo (Late Andronovo) culture: 3—wool textile, 4—photomicrographs of wool fibres.

ated materials from the Caucasus [25], Anatolia [26], and China [27–29].

This allowed us to combine radiocarbon, archaeological and geological information and to define a series of chrono-spatial stages in the spread of woollen textile technologies in the steppe and explore their wider cultural historical significance.

Ten samples of wool and animal bone were dated at the Centre of Isotope investigation of the Groningen University, the Netherlands; five samples of textiles and wood at the Poznan Radiocarbon laboratory, Poland; six textile and wood samples were dated as a collaboration between the Laboratory of radiocarbon dating and electronic microscopy, Institute of Geo-



**Fig. 3.** Summary of the modelled radiocarbon dates, revealing a series of broad phases in the spread of woollen textiles and associated technologies. Made using OxCal v4.3.2 [22].

graphy, Russian Academy of Sciences and the Centre of Isotope investigation, University of Georgia, USA; and two samples of textile and leather at the Oxford Radiocarbon Accelerator Unit, University of Oxford, UK.

## RESULTS

AMS data  $^{14}\text{C}$  obtained from samples of woollen textiles and other directly associated materials allow us, for the first time to discuss a series of phases in the appearance and spread of wool fibres and fabrics in northern Eurasia during the Bronze Age (Table 1, Fig. 3). In Fig. 4, the radiocarbon results are superimposed upon a map of northern Eurasia.

To investigate these data more robustly, a Bayesian model was constructed, placing the data into phases (using the *Phase* command in OxCal 4.3.2) based on their cultural associations and geographical location. No prior assumptions about the chronological order of these “phases.” The chronological relationship of the modelled dates for the lower “boundaries” of each phase (*Boundary* command) was statistically checked using the *Difference* function in OxCal 4.3 based on a previously published approach [30]. In the subsequent

descriptions of our results, we employ the “modelled dates” for individual samples and the overall probability distributions for each phase (generated using the *Date* function in OxCal 4.3).

## DISCUSSION

The results obtained show a clear, if somewhat extended, chronological sequence that correlates well with the relative chronology of Bronze Age cultures across northern Eurasia, enabling us to identify the cultural communities associated with the transmission of these innovative technologies for the production of woven woollen fabrics. It is quite evident that the pastoralist cultures of the Eastern European steppe transferred these traditions to their neighbours in the forest zone of Eastern Europe and further to the forest-steppe and steppe regions of the Volga region and Urals, and ultimately into Kazakhstan, Xinjiang, and South Siberia (Table 2).

The earliest date for wool in our database was obtained from the late Maykop culture from a northern Caucasus. It dates to 2910–2600 calBC (GrA-21334) and correlates with another AMS  $^{14}\text{C}$  date obtained on animal bone from the same grave (GrA-24441) [31].

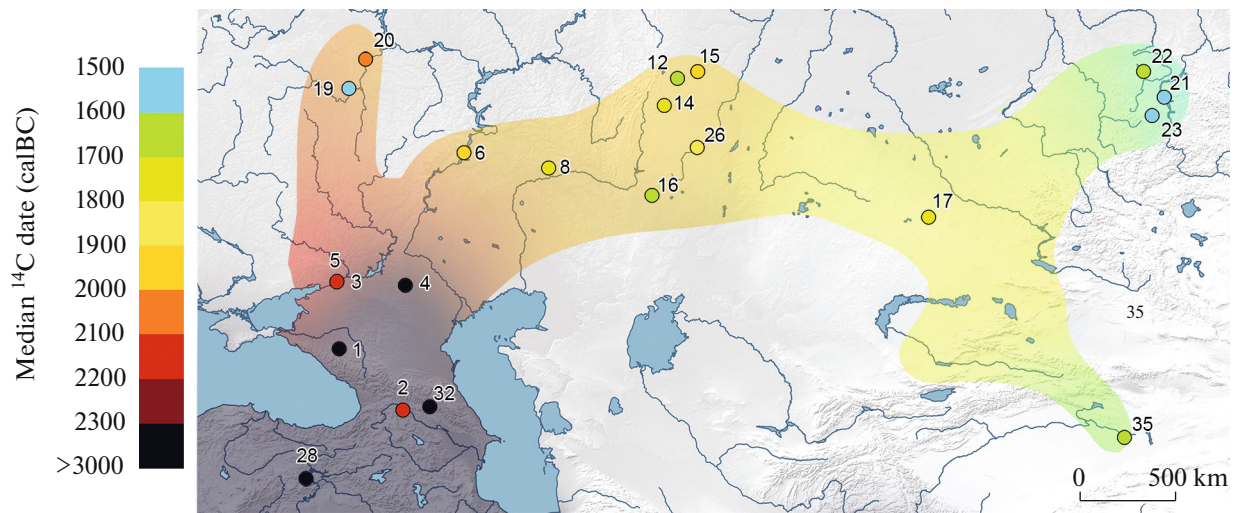
**Table 1.** <sup>14</sup>C data of wool, mixed cotton/wool textile, animal bones, nuts, wood, and leather from Bronze Age sites of northern Eurasia

Lab no.	Sample	Date (BP) ±	Calibrated range (unmodelled)						δ <sup>13</sup> C	δ <sup>15</sup> N		
			from	to	%	from	to	%				
Ua-18081	Arslian Tepe, Royal tomb	4355	65	Wood	3086	2900	68.2	3327	2879	95.5	—	—
GrA-21334	Tsarskaya, k. 2, g. 1	4200	60	Wool-cotton textile	2893	2680	68.2	2910	2601	95.4	-29.2	—
GrM-24441	Tsarskaya, k. 2, g. 1	4270	45	Deer teeth	2925	2780	68.2	3018	2701	95.4	-22.1	4
RTD-7520-A	Ananauri Big kurgan 3	3922	15	Haselnut shells	-2470	-2350	68.2	-2474	-2346	95.4	—	—
IGANams-6418	Bedeni Kurgan	3710	25	Wool (textile)	-2140	-2039	68.2	-2197	-2030	95.4	—	—
IGANams7004	Yergueni, kurgan 6, grave 3	3890	20	Wood	-2456	-2347	68.2	-2464	-2299	95.4	—	—
Ua-21407	Shakhaevskaya, kurgan 4, grave 32	3745	45	Seeds	-2268	-2043	68.2	-2291	-2027	95.4	-20.7	—
Poz-111665	Bugurusta, kurgan 5, grave 11	3715	35	Wool (textile)	-2194	-2037	68.2	-2206	-1981	95.4	—	—
IGANams-6138	Borisoglebovsky, grave 2	3715	20	Wood	-2036	-1951	68.2	-2133	-1921	95.4	—	—
Poz-106316	Borisoglebovsky, grave 2	3640	30	Wood	-2187	-2042	68.3	-2196	-2034	95.4	—	—
Poz-106315	Berezovy Rog, grave 20	3175	30	Wool (textile)	-1496	-1421	68.2	-1506	-1402	95.4	-23.8	6.8
GrM-12260	Alexeevsky II, grave 8	3485	25	Wool (textile)	-1877	-1761	68.2	-1886	-1703	95.4	-28	8.3
GrM-15221	Gerasimovka III, kurgan 1, grave 3	3400	20	Wool (textile)	-1739	-1665	68.2	-1746	-1640	95.4	-23.8	8.9
IGANams-7216	Gerasimovka III, kurgan 1, grave 3	3355	20	Wool (textile)	-1681	-1623	68.2	-1734	-1611	95.4	—	—
OxA-39019	Gerasimovka III, kurgan 1, grave 3	3396	19	Leather	-1737	-1663	68.2	-1745	-1637	95.4	—	—
GrM-14811	Alakulsky, kurgan 27, grave 7	3485	20	Wool (textile)	-1877	-1766	68.2	-1882	-1748	95.4	-22.2	7.6
GrM-14460	Stepnoye VII, complex 8, grave 2	3479	19	Wool (textile)	-1876	-1751	68.2	-1881	-1745	95.4	-23.8	6.2
IGANams-5648	Stepnoye VII, complex 8	3440	25	Wool (textile)	-1860	-1692	68.2	-1877	-1683	95.5	—	—
IGANams-5647	Stepnoye VII, complex 8	3380	25	(Human)	-1730	-1637	68.2	-1743	-1621	95.4	—	—

Table 1. (Contd.)

Lab no.	Sample	Date (BP) ±	Sample	Calibrated range (unmodelled)							
				from	to	%	from	to	%	$\delta^{13}\text{C}$	$\delta^{15}\text{N}$
AA-78374-78378	Lisakovsky, kurgan 1, grave 1	3445	Wood	-1871	-1691	68.2	-1883	-1662	95.4	-	-
Poz-102983	Ushkatinsky I, kurgan 2, grave 7	3360	Wool (textile)	-1733	-1613	68.2	-1746	-1531	95.4	-22.9	7.2
GrM-15222	Chernyaki II, grave 13, sample 8	3320	Wool (textile)	-1631	-1545	68.2	-1660	-1530	95.4	-23.3	6
Eastern Kazakhstan and Xinjiang, Alakul' and Xiaohe-Gumugou culture, PHASE IV (C)											
GrM-15972	Tyndyk	3420	Wool (textile)	-1759	-1664	68.2	-1876	-1627	95.4	-21.5	9.3
BA05805	Xiaohe, M23	3415	Wool (felt fragment)	-1759	-1645	68.2	-1877	-1622	95.4	-	-
BA05798	Xiaohe, M75:16	3365	Wool (felt hat fragment)	-1732	-1616	68.2	-1749	-1532	95.4	-	-
BA05802	Xiaohe, M2:12	3360	Wool (felt hat fragment)	-1733	-1613	68.2	-1746	-1531	95.4	-	-
BA05801	Xiaohe, M117	3355	Wool (cloak fragment)	-1732	-1611	68.2	-1744	-1531	95.4	-	-
BA05791	Xiaohe, M29:20	3225	Seed/Grain (wheat)	-1520	-1449	68.2	-1607	-1429	95.4	-	-
BA05797	Xiaohe, M292	3350	Wool (cloak fragment)	-1732	-1549	68.1	-1749	-1509	95.4	-	-
BA05795	Xiaohe, M2:18-7	3200	Seed/Grain (millet)	-1503	-1433	68.2	-1607	-1404	95.4	-	-
BA05796	Xiaohe, M92:23	3290	Seed/Grain (millet)	-1616	-1521	68.2	-1664	-1459	95.4	-	-
BA05804*	Xiaohe, M23	3545	Seed/Grain (millet)	-1945	-1779	68.2	-2011	-1756	95.4	-	-
BA05793	Xiaohe, M34:14	3240	Seed/Grain (millet)	-1602	-1450	68.2	-1612	-1436	95.4	-	-
BA05794	Xiaohe, M2: 18-3	3305	Seed/Grain (wheat)	-1626	-1529	68.2	-1684	-1501	95.4	-	-
BA05803	Xiaohe, M17:12	3375	Seed/Grain (wheat)	-1736	-1624	68.2	-1763	-1534	95.4	-	-
—*	Gumugou	3525	Wood (Coffin)	-1939	-1755	68.2	-2036	-1665	95.4	-	-
—*	Keliyahe (N cemetery), n.d.	3306	Wool (cord)	-1621	-1533	68.2	-1658	-1507	95.4	-	-
—*	Keliyahe (N cemetery), n.d.	3315	Wool (felt fragment)	-1627	-1534	68.2	-1662	-1521	95.4	-	-
—*	Keliyahe (N cemetery), n.d.	3239	Wool (felt fragment)	-1597	-1453	68.2	-1610	-1439	95.4	-	-
—*	Keliyahe (N cemetery), n.d.	3302	Wool (felt fragment)	-1636	-1509	68.2	-1735	-1450	95.4	-	-
Southern Siberia, Fedorovka (Late Andronovo) and Late Pozdnakovo culture—PHASE V											
Poz-102750	Uzhur, kurgan 47, textile	3220	Wool (textile)	-1519	-1443	68.2	-1608	-1422	95.4	-22	-
GrM-14458	Uzhur, kurgan 47, textile	3313	Wool (textile)	-1624	-1535	68.1	-1639	-1528	95.4	-22.3	6.7
GrM-14459	Uibat, grave 2, textile	3121	Wool (textile)	-1427	-1325	68.2	-1436	-1306	95.4	-20.7	9.2
OxA-38960	Ust'-Erba,	3114	Wool (textile)	-1422	-1320	68.2	-1435	-1302	95.4	-21.73	-

\*In the publication [28] the lab. no. is missing.



**Fig. 4.** (Color online) Spatial summary of the radiocarbon dates for early woollen textiles displayed site-by-site across northern Eurasia.

This date correlates with the date for a wool textile from the “Royal tomb” from Anatolia (Arslantepe) [2, 26]. But the North Caucasus textile is made from a mix of wool and cotton yarns. This garment could be non-local, and imported from some south-eastern Near east cultural environment, or from areas located to the south. Cotton is known from sites in the Kachi Plain of central Baluchistan since the 6th millennium BC and in northern Arabia and the Levant since the 4th millennium BC [32, 33]. The only fibres identified in textiles from earlier periods in the Caucasus were flax and wild plant fibres [14, 34, 35].

This preference for the use of plant fibres in textile production, as well as the chronological gap between the  $^{14}\text{C}$ -date of the cotton-wool textile from Tsarskaya and the  $^{14}\text{C}$ -dates obtained from other Caucasian woollen textiles (or associated material)—Ananauri Kurgan III (2470–2350 calBC, RTD-7520-A) [25] and woollen cord from Bedeni (2140–2040 calBC,

IGANams-6418)—highlights the absence of a stable technological tradition of woollen textile production in the region in this time. It may have taken several centuries for the weaving of wool fibres to become an established craft choice outside southwestern Asia and Anatolia. It seems significant that the  $^{14}\text{C}$  data from the Catacomb and Bedeni culture graves at Shakhavsky, Yergueni and Bugurusta show the introduction of wool textile into the eastern European steppe in the same period, 2400–2000 calBC (68%).

This correspondence in date suggests that the transmission of this technology was a result of contact between communities in the steppe and their southern neighbours. It is interesting to note that the earliest South Caucasian textile indicates the use of a blend of plant fibres and wool, though the plant fibre selected in both these cases was flax; the steppe textiles of this time were pure wool.

**Table 2.** Calibrated *Date* intervals for the various geographical phases (modelled data)

	Modelled calibrated date (BC)					
	from	to	%	from	to	%
Anatolia	–3075	–2675	68.2	–3275	–1950	95.4
Maykop	–2950	–2650	68.2	–3125	–2200	95.4
South Caucasus	–2550	–1925	68.2	–2900	–1525	95.4
Steppes of the Eastern Europe	–2425	–2000	68.2	–2750	–1675	95.4
Forests of the Eastern Europe	–2150	–1900	68.2	–2325	–1700	95.4
Volga and Ural	–1775	–1600	68.2	–1925	–1475	95.4
Trans Ural and Kazakhstan	–1775	1600	68.2	–1900	–1500	95.4
Xinjiang	–1675	–1500	68.2	–1800	–1425	95.4
South Siberia	–1550	–1325	68.2	–1750	–1225	95.4



Moving northwards, we see a steady trend in the date of early woollen textiles. The samples from the Early Pozdnyakovo (Borisoglebovsky) burials (from the eastern European forest) date between 2150–1900 calBC (68%). But to the east there is a far more dramatic transmission. All textiles associated with the Timber-grave and Alakul burials from the steppe areas of the Volga, Urals and Kazakhstan are dated between 1925–1475 calBC (95%) or 1775–1625 calBC (68%). Dates previously obtained on woven textiles and associated materials from Xinjiang Province (western China) are almost synchronous with this trend 1675–1500 calBC (68%) or 1800–1425 calBC (95%). The southern Siberian Federovo (Late Andronovo) textiles date between 1550–1325 calBC (68%) or 1750–1225 calBC (95%).

Thus, new  $^{14}\text{C}$  data indicate that wool textiles moved from the south to the north, where they were rapidly assimilated into local technical systems. This assimilation and the emergence of a secondary products economy based (at least in part) on woollen textiles was likely facilitated by the widespread pre-existence of mobile sheep/goat herding, which became a dominant economic model during the mid-third millennium BC [15, 36].

In the last quarter of the third millennium BC a wider preference for wool textile gradually spread, stretching north into the forest-steppe and forest zone. Within 250 years the production of wool textiles was fully integrated into the social economy of Eurasian pastoralists and wool textiles became increasingly widespread across northern Eurasia, spreading east towards the Urals and across Siberia and Kazakhstan. The  $^{14}\text{C}$  dates associated with the earliest samples appear to trace a rapid dispersal across the central steppe and a general trend from west to east. The  $^{14}\text{C}$  data obtained from the analysis of woven wool textiles and felt from the sites of the Xiaohe-Gumugou culture [29] indicate the rapid spread of this technology. Wool textiles in Xinjiang certainly appeared a little later than those of the South Caucasus, the steppe Catacomb culture, and the forest zone cultures of Eastern Europe. However, these fabrics are essentially synchronous with those from Alakul and Timber-grave textiles of the Volga region, the Urals and Kazakhstan.

Thus, the obtained  $^{14}\text{C}$  AMS dates clearly record two geographic trends in the spread of wool fibre. Initially from south to north and then, far more rapidly, from west to east.

## CONCLUSIONS

Direct radiocarbon dating of the Bronze Age wool textiles and synchronous carbon-contained samples enables new details to be added to our understanding of the chronology of early wool economy and associated textile technologies and its transmission within northern Eurasia. Chronological phases and compar-

ative analyses (including  $^{14}\text{C}$ -dates from Anatolia, South Caucasus, and China) reveal different phases of cultural and technological exchanges between the Near East and the Caucasus and special role of steppe groups (a few generations of weavers) in a dispersal spanning of new technology during the third millennium BC (Figs. 3, 4). Chronological and historical phases of the process are summarized as follows.

—After 3300 calBC: early exchanges of prestige goods across Near East and the North Caucasus, with wool-cotton textiles moving as part of the elite exchange networks; mixed wool-cotton textile dates around 2910–2600 calBC.

—The mid third millennium BC: spread of wool textile technologies and associated management strategies out of the Near East/Anatolia and into the southern Caucasus; according to  $^{14}\text{C}$  data obtained for textiles and synchronous samples this happened between 2550–1925 calBC; an almost synchronous date was obtained from the dates of the northern steppe regions, suggesting that the spread of innovative technology from the South Caucasus to the steppe zone and further north up to the forest zone occurred as part of the same process between 2450–1900 calBC.

—Between 1925–1775 calBC there was rapid eastward transmission of the wool (and associated technologies) across the steppe and forest-steppe of the Volga and southern Urals, out across Kazakhstan and into western China between 1700–1225 calBC. This same process of transmission through the steppe ultimately brought woven wool textiles into societies around the western Altai and the Sayan Mountains of southern Siberia.

Textile communities in the Caucasus and the adjacent areas of the steppe (Bedeni, Catacomb and Babino synchronous cultures) shared the same economic pathways and began to communicate and exchange technological knowledge of wool textile production during the second half of the third millennium BC, stimulating the expansion of pre-existing local networks of exchange. In about 200 years, these networks brought a new approach to the management and exploitation of animal herds from communities in the steppe and the piedmont area of the northern Caucasus. A new secondary product appeared: woven woollen textiles. Was this the result of imported livestock or an intensive phase of selective breeding by Catacomb culture shepherds? What is clear from the early production of wool items in the steppe is that it was a small scale, domestic activity of the local communities.

A far more rapid transmission occurred during the early second millennium BC through culturally connected communities of pastoralists known to archaeologists as the Timber-grave culture in the Middle Volga and Ural regions, Alakul (Early Andronovo) in

the Urals region, and northern Kazakhstan as well as Federovo (Late Andronovo) in southern Siberia.

By the mid second millennium BC, through the steppe and forest-steppe zones of northern Eurasia—from the Caucasus and the adjacent steppe to Kazakhstan—a “Wool Road” consisting of extensive networks of multi-direction and multicultural exchange, ran through the communities of Eurasia both in and around the steppe zone.

This pattern of transmission was operating in parallel with the spread of wool technologies through the very different cultural environment of Western and Central Asia [37].

We assume that the wool clothing found in the Tarim Basin fits within the same processes of transmission through this northern Eurasian “Wool Road.” The coincidence of the date of these finds, various similarities seen in the details of their clothing with those from Timber-grave and Alakul cultures of the Volga region, the Urals, Kazakhstan, and a basic similarity of their technological traditions suggest that the origins of these Chinese woollen textiles and textiles of the Eurasian steppe and forest zones are closely related.

Weavers shared a preference for red-coloured dyes and a special interest in composite hats or headdresses ornamented with feathers and other organic materials [28, 38]. They also showed a strong preference for the use of leather, fur, and wool textiles together in the production of composite garments.

These tendencies seem to be in contrast with wool items from the southern Caucasus dated to the second half of the third millennium BC, known for the use of combined wool and plant fibres and their distinctive patterns of weaving [34].

In summary, the results of this study define a clear spatio-temporal trajectory of the emergence and rapid spread of woven woollen textile production across northern Eurasia and offers new insight into the processes underlying this transformation.

#### FUNDING

This study was supported by the Russian Fund of Basic Research (18-09-00015) and was conducted as part of the FLAME project, which has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement no. 670010 (FLAME).

#### REFERENCES

1. E. J. W. Barber, *Prehistoric Textiles* (Princeton Univ. Press, Princeton, 1992).
2. M. Frangipane, A. Strand, R. Laurito, et al., *Paleorient*, No. 35, 5 (2009).
3. *Textiles and Textile Production in Europe from Prehistory to AD 400*, Ed. by M. Gleba and U. Mannering (Oxbow Books, Oxford, 2012).
4. L. B. Jørgensen, *North European Textile until AD 1000* (Aarhus Univ. Press, Aarhus, 2015).
5. C. Becker, N. Benecke, A. Grabundžija, et al., *Topoi J. Ancient Studies*, No. 6, 102 (2016).
6. A. Zazzo, A. Marie, et al., *J. Archaeol. Sci.*, No. 110, 1 (2019).
7. M. L. Ryder, *Oxford J. Archaeol.*, No. 12 (3), 305 (1993).
8. J. McCorrison, *Curr. Anthropol.*, No. 38, 517 (1997).
9. I. Good, *The Bronze Age and Early Iron Age Peoples of Eastern Central Asia*, Ed. by V. V. Mair (Univ. Pennsylvania Museum, PA, 1998), Vol. 2, p. 656.
10. I. L. Good, “The ecology of exchange: Textiles from Shahr-i-Sokhta, Eastern Iran,” ProQuest Dissertation of Theses (Philadelphia, 1999).
11. *Textile Terminologies in the Ancient Near East and Mediterranean from the Third to the First Millennia BC*, Ed. by C. Michel and M.-L. V. Nosch (Oxbow Books, Oxford, 2010), Vol. 8.
12. R. Firth, in *Prehistoric, Ancient Near Eastern and Aegean Textiles and Dress. An Interdisciplinary Anthology*, Vol. 18 of *Ancient Textile Series*, Ed. by M. Harlow et al. (Oxbow Books, Oxford, 2014), p. 57.
13. E. Kvavadze, A. Sagona, I. Martkoplshvili, et al., *J. Archaeol. Sci. Rep.*, No. 2, 235 (2015).  
<https://doi.org/10.1016/j.jasrep.2015.02.003>
14. N. I. Shishlina, O. V. Orfinskaya, and V. P. Golikov, *Oxford J. Archaeol.*, No. 22 (4), 331 (2003).  
<https://doi.org/10.1046/j.1468-0092>
15. N. I. Shishlina, *Reconstruction of the Bronze Age of the Caspian Steppes. Life Styles and Life Ways of Pastoral Nomads*, No. 1876 of *British Archaeological Reports International Series* (Archaeopress, Oxford, 2008).
16. E. V. Kupriyanova and S. V. Taskaev, *Vestn. Arkheol. Antropol. Etnogr.*, No. 2 (41), 17 (2018).
17. O. V. Orfinskaya, V. P. Golikov, and N. I. Shishlina, “Bronze Age textiles of the Eurasian steppes,” *Tr. GIM*, No. 109, 58 (1999).
18. N. Shishlina, V. Golikov, and O. Orfinskaya, *BAR Ser.*, No. 890, 109 (2000).
19. N. Shishlina and O. Orfinskaya, *Archaeol. Textiles Newsl.*, No. 40, 6 (2005).
20. E. S. Azarov, V. M. Pozhidaev, N. I. Shishlina, et al., *Kratk. Soobshch. Inst. Arkheol.*, No. 244, 391 (2016).
21. N. I. Shishlina, O. V. Orfinskaya, N. Yu. Petrova, and O. V. Kuznetsova, in *Proceedings of the International Conference on Antiquities of Eastern Europe, Central Asia and Southern Siberia in the Context of Connections and Interactions in the Eurasian Cultural Space (New Data and Concepts)*, Ed. by L. B. Kircho (IIMK, St. Petersburg, 2019), p. 257.  
<https://doi.org/10.31600/978-5-907053-34-2-257-258>
22. R. C. Bronk, *Radiocarbon*, No. 51, 337 (2009).

23. P. J. Reimer, E. Bard, A. Bayliss, et al., *Radiocarbon*, No. 55, 1869 (2013).
24. I. C. C. von Holstein, P. W. Rogers, O. E. Craig, et al., *PLoS One*, No. 11, e0162330 (2016).  
<https://doi.org/10.1371/journal.pone.0162330>
25. E. Boaretto, R. Lev, L. Regev, et al., in *Ananauri Big Kurgan 3* (Tbilisi Georg. Natl. Museum, Tbilisi, 2016), p. 284.
26. M. Frangipane, G. M. di Nocera, A. Hauptmann, et al., *Paleorient* 27, 105 (2001).
27. R. Flad, S. Li, X. Wu, et al., *Holocene*, No. 17, 555 (2010).
28. J. P. Mallory and V. H. Mair, *The Tarim Mummies* (Thames Hudson, London, 2000).
29. B. Wang, in *Archaeological Culture of the Peacock River Bronze Age. The Bronze Age of the Peacock River*, Ed. by B. Wang (Science Press, Beijing, 2017), p. 3.
30. T. Long, C. Leipe, G. Jin, et al., *Nat. Plants*, No. 4, 272 (2018).
31. V. Trifonov, N. Shishlina, O. Chernova, et al., *Paleorient*, No. 1, 69 (2019).
32. A. Betts, K. van der Borg, A. de Jong, et al., *J. Archaeol. Sci.*, No. 21, 489 (1994).
33. Ch. Moulherat, J. Tengberg, and B. Mille, *J. Archaeol. Sci.*, No. 29, 1393 (2002).
34. N. Kalandadze, E. Sakhvadze, Z. Makharadze, et al., in *Ananauri Big Kurgan 3* (Tbilisi Georg. Natl. Museum, Tbilisi, 2016), p. 127.
35. E. Kvavadze, G. Narimanishvili, and L. Bitadze, *Veget. History Archaeobot.*, No. 19, 479 (2010).
36. P. A. Kosintsev, in *Material Culture of the Samara River Basin Population during the Bronze Age*, Ed. by Yu. I. Kolev, P. F. Kuznetsov, and O. D. Mochalov (SamGPU, Samara, 2003), p. 126 [in Russian].
37. I. Good, in *Companion to the Archaeology of Ancient Near East*, Ed. by D. N. Potts (Wiley-Blackwell, Oxford, 2012), p. 336.
38. A. Wiczorek and Ch. Lind, *Ursprünge der Seidenstrasse. Sensationelle Neufunde aus Xinjiang, China* (Reiss-Engelhorn-Museen Mannheim, Stuttgart, 2007).

*Translated by P. Hommel and N. Shishlina*