

¹⁴C CHRONOLOGY OF BURIAL GROUNDS OF THE ANDRONOVO PERIOD (MIDDLE BRONZE AGE) IN BARABA FOREST STEPPE, WESTERN SIBERIA

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ABSTRACT. This paper focuses on the chronology of Middle Bronze Age complexes in the Baraba forest steppe (western Siberia). Three sites were radiocarbon dated, Stary Tartas 4, Sopka 2, and Tartas 1. The Late Krotovo culture was dated to the 18–19th centuries BC, the Andronovo complex (Fedorovo stage) to the 15–18th centuries BC, and the Mixed Andronovo complex dated to the 15–17th centuries BC. These values are some 300–500 yr older than previously thought, and the new results are consistent with ¹⁴C dates of the Andronovo cultural complex in northern Eurasia. Based on these data, the 15th century BC is the upper chronological limit of the Andronovo period.

INTRODUCTION

The Andronovo cultural complex (hereafter “culture”) is one of the main Bronze Age archaeological complexes of Eurasia. It occupied a wide territory, including the southern parts of west Siberia and the Urals, and western Central Asia. The Andronovo culture extended to the west to the Volga River, where it connected with the Srubnaya culture; in the east, it spread to the upper Yenisei River (Minusinsk Basin). In the south, some separate Andronovo sites were found in the mountain systems of Kopetdag (Turkmenistan), Pamir (Tajikistan), and Tian Shan (Kyrgyzstan). Therefore, the northern limit of the Andronovo culture coincides with the boundary between the forest steppe and taiga zones. The Andronovo culture is reflected in the archaeological complexes of a large part of Eurasia, and potentially carries information about the historical fate of the Indo-Iranians (Kuzmina 2007).

The Andronovo culture was established by Teploukhov (1927). In general periodization of Siberian antiquity, it marks the beginning of the Middle Bronze Age, the period of development of metallurgy and distribution of metal objects in the region (Gryaznov 1956; see also Chernykh 1992, 2009). According to Molodin (1985), in the west Siberian forest steppe the Andronovo culture represents the second stage of the Middle Bronze Age after the Seima-Turbino stage.

The Andronovo culture encountered challenges in socioeconomic and military organization, the development of wheeled vehicles, and the origin of the Indo-Iranian peoples (e.g. Zdanovich and Zdanovich 2002; Kuzmina 2007). Chronology and periodization of Andronovo antiquities in different parts of Eurasian steppe (Petrovo, Alakul, and Fedorovo stages) are also debatable (e.g. Zdanovich 1988; Hanks and al. 2007). Some of the main issues for the Andronovo culture are related to migrations, the number of migration waves, the characteristics of the contacts between the 2 groups (migrants and aborigines), and the time when these events took place (Salnikov 1967; Potemkina 1985; Matveev 1998; Koryakova and Epimakhov 2007; Tkacheva and Tkachev 2008). Over the past 2 decades, the radiocarbon database for the Andronovo culture has significantly increased. As a result, Bronze Age complexes of northern Eurasia, including Andronovo sites, are believed to be older than previously thought (Chernykh et al. 2004; Görsdorf et al. 2004; Shishlina et al. 2007; Panyushkina et al. 2008; Svyatko et al. 2009). This study is based on the materials from the northern periphery of the Andronovo world, the burial grounds of the Baraba forest steppe.

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Our ultimate goal is to determine the migration time of the Andronovo tribes to the northeast, with possible reconstruction of the stages of their penetration, and to compare our ^{14}C data with those from Andronovo complexes in neighboring regions. Another task is the control dating of the same samples in different laboratories. In addition to ^{14}C dating the key sites, this study is based on comparative-typological analysis of grave goods (bronze tools and ornaments, and pottery), as well as on comparative analysis of elements in burial practices. Some of the ^{14}C dates from the Tartas 1 site were published previously (Molodin et al. 2008). Here, we present the most complete set of ^{14}C dates from the Andronovo period (including Late Krotovo, Andronovo, and Mixed Andronovo cultural complexes) in the Baraba forest steppe.

ARCHAEOLOGICAL COMPLEXES

The studied region is located in the southern part of west Siberia (Figure 1). The Baraba forest steppe is situated between the Irtysh and Ob rivers (Gvozdetsky and Mikhailov 1978:222–4), bordering the Kulunda steppe to the south, while in the north reaching the west Siberian taiga and the Vasyugan peatbogs (e.g. Tishkov 2002:222–4). Traditionally, it is thought that penetration of the Andronovo population into the Baraba forest steppe occurred from the south (central and northern Kazakhstan).



Figure 1 Location of the Tartas 1, Sopka 2/5, and Stary Tartas 4 sites (black dot) in the Baraba forest steppe (shaded area)

We have 3 types of populations with different cultural signatures in the studied area: migrants (Andronovo culture, particularly its Fedorovo stage); aborigines (Late Krotovo culture); and complexes that were formed as a result of kinship interaction between migrants and aborigines (Mixed Andronovo culture). These archaeological complexes were studied at 3 burial grounds, Stary Tartas 4, Sopka 2/5, and Tartas 1. The sites are situated near each other at the confluence of the Tartas and Om rivers (55°37'N, 76°44'E), with a distance between sites of 1.5–2.5 km. The number of samples and material dated for each site are listed in Table 1.

Table 1 ¹⁴C dates from the Middle Bronze Age sites of the Baraba forest steppe.

| Site, complex, feature | Material dated ^a | Lab nr | ¹⁴ C date (BP) | Calibrated range (±2 σ) start (relative area) end | δ ¹³ C (‰) ^b |
|---|-----------------------------|--------------|---------------------------|--|------------------------------------|
| Tartas 1 (Late Krotovo culture) | | | | | |
| Grave 20 | Collagen | Bln-5839L+LI | 3435 ± 26 | 1880 (12.4%) 1840 BC 1830 (83.0%) 1660 BC | -21.1 |
| Grave 25 | Collagen | Bln-5840L+LI | 3419 ± 18 | 1745 (22.2%) 1725 BC 1720 (46.0%) 1690 BC | -21.5 |
| Grave 25 | Collagen | SOAN-7129-2 | 3400 ± 35 | 1870 (2.7%) 1840 BC 1780 (92.7%) 1610 BC | |
| Grave 71 | Collagen | SOAN-7130 | 3385 ± 55 | 1880 (4.5%) 1840 BC 1820 (2.3%) 1790 BC 1780 (88.5%) 1520 BC | |
| Cult pit 109 | Collagen* | KIA-29037 | 3324 ± 26 | 1683 (8.6%) 1667 BC 1662 (7.6%) 1648 BC 1642 (79.2%) 1523 BC | -21.7 |
| Tartas 1 (Mixed Andronovo culture) | | | | | |
| Grave 114 | Collagen | SOAN-7125 | 3215 ± 50 | 1620 (95.4%) 1400 BC | |
| Grave 121 | Collagen | SOAN-7124-2 | 3275 ± 50 | 1680 (95.4%) 1440 BC | |
| Grave 121 | Collagen | Bln-5903LI | 3425 ± 28 | 1880 (7.8%) 1840 BC 1820 (2.3%) 1790 BC 1780 (85.3%) 1630 BC | -21.7 |
| Grave 124 | Collagen | Bln-5837L+LI | 3399 ± 34 | 1870 (2.2%) 1840 BC 1780 (93.2%) 1610 BC | -21.1 |
| Grave 141 | Collagen | SOAN-7127 | 3235 ± 50 | 1630 (95.4%) 1410 BC | |
| Grave 144 | Collagen | Bln-5838L+LI | 3442 ± 35 | 1890 (95.4%) 1660 BC | -21.1 |
| Grave 180 | Collagen | SOAN-7122 | 3310 ± 80 | 1780 (95.4%) 1420 BC | |
| Grave 182 | Collagen | SOAN-7119 | 3235 ± 55 | 1640 (95.4%) 1400 BC | |
| Grave 189 | Collagen | SOAN-7118 | 3310 ± 30 | 1680 (95.4%) 1510 BC | -21.7 |
| Grave 193 | Collagen | SOAN-7123 | 3225 ± 40 | 1610 (95.4%) 1420 BC | |
| Grave 196 | Collagen | SOAN-7120 | 3270 ± 60 | 1690 (95.4%) 1430 BC | |
| Grave 208 | Collagen | SOAN-7121 | 3295 ± 65 | 1740 (3.3%) 1710 BC 1700 (92.1%) 1430 BC | |
| Grave 208 | Cremated bone** | KIA-41972 | 3420 ± 30 | 1880 (6.3%) 1840 BC 1820 (1.5%) 1800 BC 1780 (87.6%) 1630 BC | |
| Grave 215 | Charcoal, bark | SOAN-7132 | 3400 ± 75 | 1880 (6.4%) 1840 BC 1820 (1.9%) 1800 BC 1780 (59.9%) 1600 BC | |
| Grave 237 | Cremated bone** | KIA-41971 | 3275 ± 45 | 1670 (95.4%) 1440 BC | |
| Grave 282 | Cremated bone** | KIA-41970 | 3010 ± 35 | 1390 (95.4%) 1120 BC | |
| Sopka 2/5 (Late Krotovo culture) | | | | | |
| Grave 119 | Collagen | Le-9076 | 3210 ± 130 | 1900 (95.4%) 1100 BC | |
| Grave 134 | Collagen | Le-9075 | 3180 ± 90 | 1690 (95.4%) 1250 BC | |
| Grave 325 | Collagen | SOAN-7726 | 3540 ± 75 | 2130 (2.6%) 2080 BC 2050 (92.8%) 1680 BC | -18.4 |
| Grave 334 | Collagen | SOAN-7720 | 3590 ± 100 | 2300 (95.4%) 1650 BC | -19.3 |
| Stary Tartas 4 (Andronovo culture) | | | | | |
| Kurgan 5, grave 1 | Cremated bone** | KIA-41967 | 3400 ± 35 | 1870 (2.7%) 1840 BC 1780 (92.7%) 1610 BC | |
| Kurgan 12, grave 1 | Cremated bone** | KIA-41965 | 2915 ± 35 | 1260 (4.4%) 1230 BC 1220 (91.0%) 1000 BC | |
| Kurgan 14, grave 2 | Collagen | AA-84326 | 3330 ± 60 | 1760 (93.6%) 1490 BC 1480 (1.8%) 1450 BC | -21.3 |
| Kurgan 16, grave 1 | Cremated bone** | KIA-41964 | 3245 ± 35 | 1610 (95.4%) 1430 BC | |

Table 1 ^{14}C dates from the Middle Bronze Age sites of the Baraba forest steppe. (Continued)

| Site, complex, feature | Material dated ^a | Lab nr | ^{14}C date (BP) | Calibrated range ($\pm 2\sigma$) start (relative area) end | $\delta^{13}\text{C}$ (‰) ^b |
|------------------------|-----------------------------|-----------|---------------------------|--|--|
| Kurgan 16 ^c | Cremated bone** | KIA-41966 | 3370 \pm 30 | 1750 (91.1%) 1600 BC 1580 (4.3%) 1530 BC | |
| Kurgan 17, grave 1 | Collagen | AA-84327 | 3290 \pm 60 | 1730 (1.2%) 1710 BC 1700 (94.2%) 1430 BC | -17.0 |
| Kurgan 19, grave 3 | Cremated bone** | KIA-41968 | 3165 \pm 35 | 1520 (95.4%) 1380 BC | |

^a** Horse bone is dated; ** Bioapatite is dated.

^bSOAN Laboratory does not conduct regular $\delta^{13}\text{C}$ measurements.

^cBones were collected not in grave but inside the mound.

The *Stary Tartas 4* site [in some sources *Staryi Tartas*] is represented by burial mounds (kurgans). All burials belong to the Andronovo culture. The basic burial practice is cremation, and only a few children were inhumed. The site was investigated from 1994 to 1998, with 19 kurgans excavated (Molodin et al. 2002).

The *Sopka 2* site is a very large burial ground. About 700 burials of different periods, from Neolithic to late Medieval time, were excavated. Some of the burials have kurgans. Part of a necropolis called *Sopka 2/5* contains graves of the Late Krotovo culture (Molodin 2001), and its bearers were indigenous to the studied area. The main burial practice is inhumation. The site was investigated from 1979 to 1991, with over 80 Late Krotovo graves unearthed.

The *Tartas 1* site is a burial ground without kurgans. It consists of 2 main components: Late Krotovo complexes and Mixed Andronovo ones. Burials of these 2 cultural groups are spatially separated. The Late Krotovo graves are located on the edge of a terrace, with the Mixed Andronovo ones situated deeper on the terrace. The cult pits near graves are typical for Late Krotovo burials. In these pits, animal bones and houseware items were sometimes found. The burial practice of the Late Krotovo culture is inhumation. As for the Mixed Andronovo culture, both inhumation and cremation are present, but the latter is rare. Inhumation together with cremation can sometimes be found in a grave (Figure 2, #4), while cremation alone is rarely observed (Figure 2, #2). Such a practice can be seen as possible evidence of proper Andronovo burial tradition. The site has been under investigation since 2003 (Molodin et al. 2009), and to date ~500 Middle Bronze Age burials have been excavated.

As for the burial patterns for each cultural tradition, at the studied sites the Late Krotovo culture is characterized by shallow graves (0.1–0.2 m deep) and mainly single burials (Figure 2, #1). Skeletons are in a supine position. Grave goods usually consist of bone and metal: arrowheads, daggers, needles, bronze ornaments (especially in children and women graves), and other items. Animal bones were found at times, but no ceramics were recovered. The Andronovo culture, on the other hand, is characterized by deep graves (~1 m and more). Cremated bones and ceramic vessels (from 1 to 6, but usually 2–4) were traditionally placed in the grave (Figure 2, #2). Bronze artifacts are very rare.

At the *Tartas 1* site, there are signs of a mixed burial practice that combines features of both traditions, typical for the Mixed Andronovo culture. The tradition of placing a non-cremated body in a burial pit comes from the Late Krotovo culture. The skeletons lay in a supine position. Grave goods comprise bones of domestic and wild animals and Late Krotovo houseware items (bone spoons, horn dishes, bronze knives, and other items). From the Andronovo tradition, the following features were inherited: deep graves; cremated bones, and pottery vessels that are placed into the grave, with the skeleton positioned on its side with flexed arms and legs (Figure 2, #3–4). Ceramic vessels in these graves may belong to the Andronovo, Late Krotovo, and Mixed Andronovo traditions.

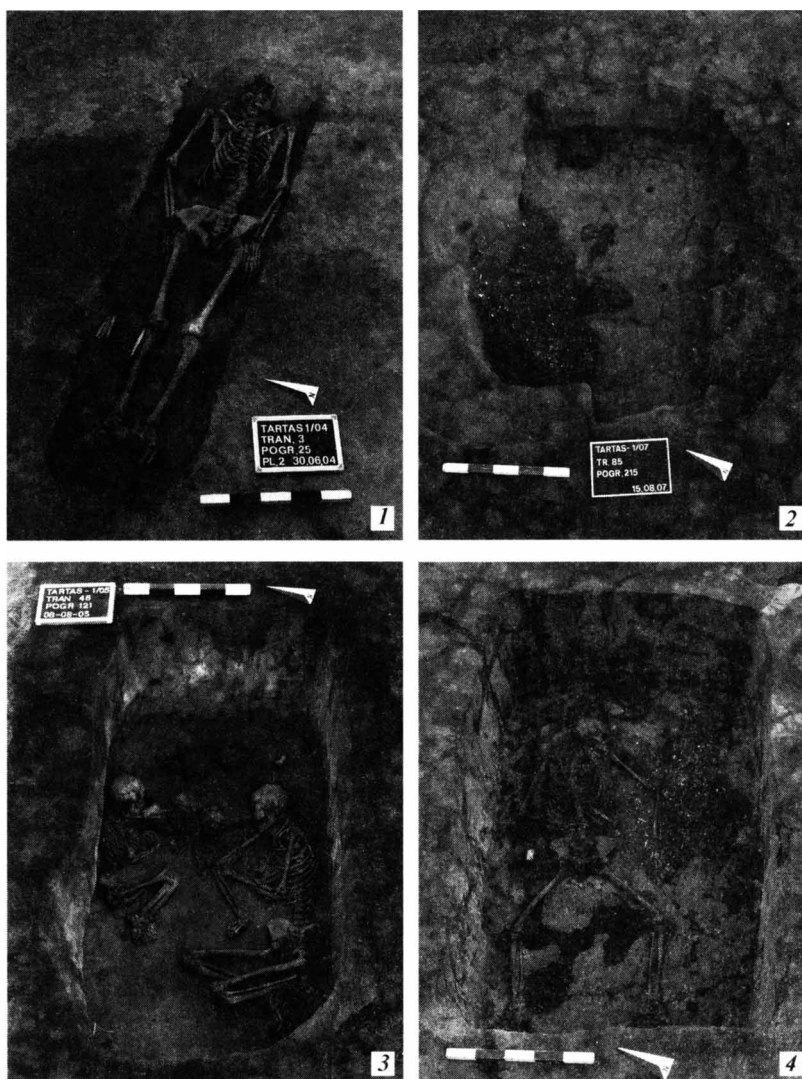


Figure 2 Ground burials of the Tartas I site: 1) Late Krotovo tradition (grave 25); 2) Andronovo tradition (grave 215); 3 and 4) Mixed Andronovo tradition (graves 121 and 208, respectively).

METHODS AND SAMPLING

¹⁴C dates were generated in the following laboratories: Institute of Geology and Mineralogy, Siberian Branch of Russian Academy of Science (Novosibirsk, Russia; lab code SOAN); Royal Institute for Cultural Heritage (Brussels, Belgium; lab code KIA); Christian-Albrechts-University (Kiel, Germany; lab code KIA); German Archaeological Institute (Berlin, Germany; lab code Bln); NSF-Arizona AMS Laboratory, University of Arizona (Tucson, USA; lab code AA); and the Institute of the History of Material Culture, Russian Academy of Science (St. Petersburg, Russia; lab code Le). The laboratories in Novosibirsk, Berlin, and St. Petersburg use liquid scintillation counting (LSC), while the others employ the accelerator mass spectrometry (AMS) method. Calibration was done using OxCal v 3.10 software (Bronk Ramsey 1995, 2001) and the IntCal04 calibration curve (Reimer et al. 2004).

The majority of ^{14}C dates (31 out of 32) are obtained on bones. Human bone collagen (22 samples), a single horse bone collagen, and cremated bones unidentified to species (either human or animal, 8 samples) were processed (Table 1). A single charcoal and bark specimen were also dated. Extraction of collagen follows routine procedures (e.g. Gördsdorf et al. 2001, 2004; Kuzmin and Orlova 2004; Kuzmin et al. 2004). As for cremated bones, the method developed by Van Strydonck et al. (2009) was used.

TRADITIONAL CHRONOLOGY AND DATING GRAVE GOODS

The traditional chronology for the Andronovo culture in western Siberia was based on 2 lines of artifact synchronization in archaeological complexes of the Far East, ancient China, and western Siberia; and eastern and southern Europe (the “eastern” and “western” lines; see Chernykh 1992). Penetration of Andronovo artifacts into the Baraba forest steppe marked the beginning of the Andronovo period in the given region.

On one hand, there are specific ceramic vessels that are typical only for the Fedorovo stage of the Andronovo culture. These are vessels of good quality with complicated geometric ornaments (Figure 3, #1). On the other hand, there are specific bronze objects typical for more general Andronovo and related archaeological complexes: adzes, axes, and darts (Figure 3, #2); and daggers (especially so-called Srubnaya-Andronovo ones; see Figure 3, #6). Women’s ornaments (bracelets with spiral endings and earrings; see Figure 3, #4), temple rings (Figure 3, #3), and “palmate pendants” (Figure 3, #5) are all products of Andronovo’s cultural sphere, and they were found in 3 cultural complexes of the Middle Bronze Age in the Baraba region. Traditionally, these objects in the Baraba forest steppe were dated to the 12–14th centuries BC (Molodin 1985).

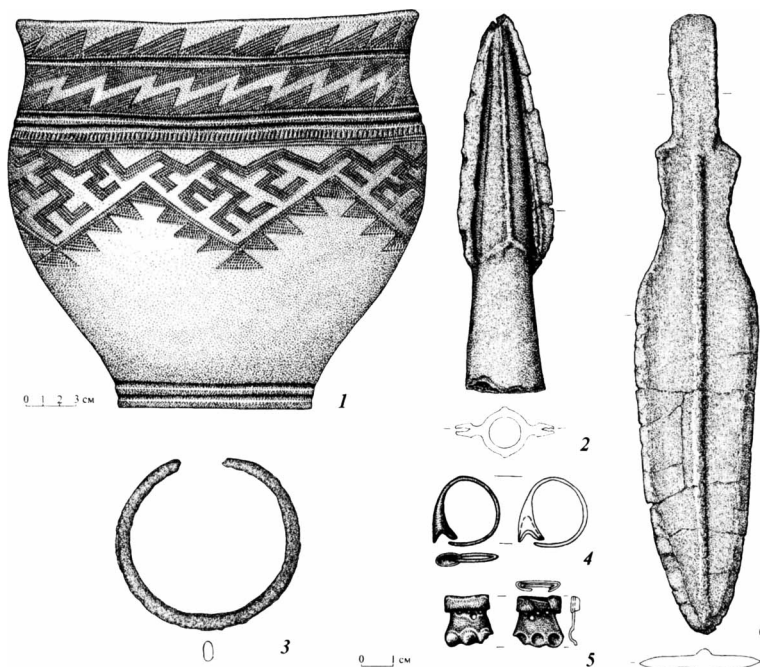


Figure 3 Grave goods from the Tartas 1 site: 1) ceramic vessel (grave 60); 2) bronze tip of dart (grave 72); 3) bronze temple ring (grave 20); 4) bronze earring (grave 133); 5) bronze palmate pendant wrapped in golden foil (grave 98); and 6) bronze dagger (grave 20).

RESULTS AND DISCUSSION

¹⁴C Dating of Non-Cremated Bones

The largest number of dates is generated for the Tartas 1 site. Sixteen values are obtained for both cultural groups (Late Krotovo and Mixed Andronovo), the majority of them on human bones. Two dates came from horse bone and charcoal (KIA-29037 and SOAN-7132, respectively). Two skeletons were dated in different laboratories (Berlin and Novosibirsk; pairs Bln-5840L+LI and SOAN-7129-2; and Bln-5903LI and SOAN-7124-2), with the results in general agreement.

It is possible to interpret these dates in 2 ways: 1) to consider the data set as a whole; and 2) to analyze dates from each laboratory separately. Therefore, outcomes will be slightly different. On the one hand, if we consider the entire data set, 2 ¹⁴C date groups will be observed: the early one (Bln-5837 to -5840L+LI, and -5903LI; and SOAN-7129-2, -7130, and -7132), and the late one (SOAN-7118 through -7127, and KIA-29037) (Figure 4). Thus, all Late Krotovo dates and part of the Mixed Andronovo values belong to the early group, and only Mixed Andronovo dates correspond to the late group. On the other hand, if we review the dates run at the Novosibirsk and Berlin laboratories separately, the following pattern can be seen. In the Berlin data set (Bln-5837 through -5840L+LI, and -5903LI), there are no dynamics in organization of the cemetery; graves of both cultures are created at the same time. However, in the Novosibirsk data set, one can see that the earlier dates (SOAN-7129-2 and -7130) belong to Late Krotovo culture, and the later dates (SOAN-7118 to -7127) are from the Mixed Andronovo complex. We argue that the Novosibirsk results are reliable because they do not contradict the Berlin data set. Also, due to the small standard deviation (up to ± 50 yr; SOAN-7118, -7119, -7123, -7124-2, -7125, and -7127), the chronology of the Mixed Andronovo complex can be placed in the 15–17th centuries BC (Figure 4).

The horse bone date (KIA-29037) is taken not from the grave but from a cult pit (see Table 1). This value corresponds with both chronological groups (see above). This result may indeed be right because cult pits were not filled deliberately but remained opened for a long time. It cannot be excluded that these pits could have been used by several generations, and the artifacts from them could be of later age in relation to the burials nearby. A single ¹⁴C date on non-bone materials (charcoal, SOAN-7132) from the Mixed Andronovo group has a relatively large standard deviation and therefore is non-informative because it overlaps both groups.

¹⁴C data from the Tartas 1 burial ground are consistent with the spatiotemporal development of the necropolis. Initially, the space along the edge of the terrace was occupied by Late Krotovo burials. Later on, the territory deeper in the terrace was filled by Mixed Andronovo burials. It is likely that the time interval between the creations of both cultural complexes was relatively small and lasted for 1–3 generations; therefore, it is almost impossible to establish it with the help of ¹⁴C dating. In the meantime, we suppose that the upper limit of the Late Krotovo burials is not younger than the 16th century BC, and the lower limit is not older than the 19th century BC ($\pm 2 \sigma$). The Mixed Andronovo graves can therefore be placed within the 15–19th centuries BC ($\pm 2 \sigma$) if the whole data set is considered (see above); but if one prefers only dates from the Novosibirsk Laboratory with small standard deviation, the age can be reduced to the 15–17th centuries BC ($\pm 2 \sigma$) (Table 1; Figure 4).

In order to confirm the chronological position of the Andronovo period in the Baraba forest steppe, we obtained collagen samples from other sites: Sopka 2/5 (Late Krotovo culture) and Stary Tartas 4 (Andronovo culture). The ¹⁴C dates from the Sopka 2/5 site have relatively large standard deviations, with their calendar ages ranging from the 12th to 23rd centuries BC ($\pm 2 \sigma$) (Figure 4). Two dates (SOAN-7720 and -7726) were generated in the Novosibirsk Laboratory, and 2 others (Le-9075

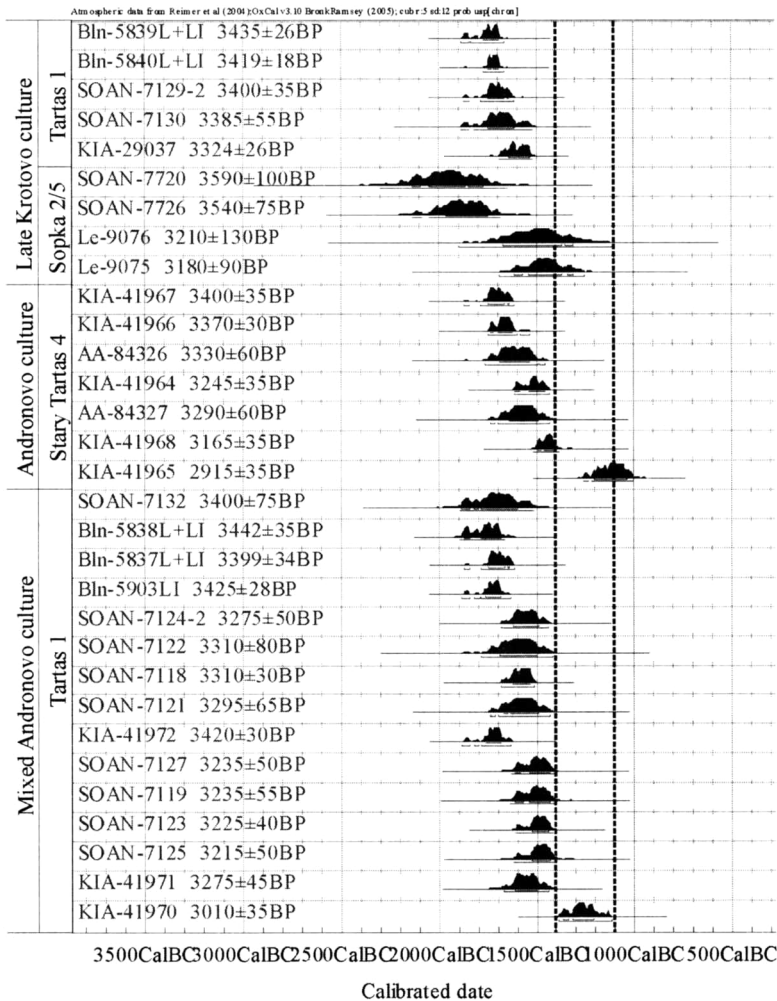


Figure 4 Calibrated dates of Middle Bronze Age complexes in the Baraba forest steppe; dashed lines represent boundaries of the traditional Andronovo period (both Andronovo and Late Krotovo complexes).

and -9076) in the St. Petersburg Laboratory (Table 1). Each pair of dates is well correlated; however, there is less agreement between the pairs. The age of Late Krotovo burials defined at Novosibirsk is 17th–22nd centuries BC, and St. Petersburg’s values placed it during the 13–20th centuries BC ($\pm 2 \sigma$) (Table 1, Figure 4). In our opinion, the results of both laboratories demonstrate the chronological unity of the Late Krotovo culture. However, it is harder to define the chronology of the Late Krotovo burial ground at Sopka 2/5 site using all 4 dates: they are intercepted only within the 17th century BC (Table 1), and this corresponds well to chronology of Late Krotovo culture at the Tartas 1 necropolis. However, it would be premature to define age of the Sopka 2/5 in particular and the Late Krotovo culture in general within the 17th century BC, and it is necessary to increase the data set for Late Krotovo culture.

Two dates (AA-84326 and -84327) were obtained for Andronovo kurgans at the Stary Tartas 4 site (Table 1). They correspond well with each other, and are within the 15–18th centuries BC. Thus, all

3 cultural groups of Andronovo period (Late Krotovo, Andronovo, and Mixed Andronovo), which reflect the process of penetration of the foreign southern steppe population into the Baraba forest steppe and its interaction with indigenous human groups, belong to the first half of the 2nd millennium BC. It is not possible to reconstruct the “microhistory” (i.e. to define the exact time of penetration of the steppe population and to estimate the assimilation period) using the ¹⁴C dating method due to its relatively low precision.

¹⁴C Dating of Cremated Bones

Three dates were obtained from the Tartas 1 site (Table 1). Two of them (KIA-41971 and -41972) correspond to the basic timeframe of the Mixed Andronovo group, and 1 date (KIA-41970) does not correspond to it (Figure 4). There are 2 dates for grave 208 (SOAN-7121 and KIA-41972), run on both cremated and non-cremated bones, and the results are concordant (Table 1; Figure 2, #4). There are 5 dates of cremated bones from the Stary Tartas 4 site, 4 of them are characterized by the same chronological limit (KIA-41964 and 41966 through 41968). These dates correspond well to 2 values of non-cremated bones from the same site (Table 1; Figure 4).

Comparison with Neighboring Regions and Other Cultures of Baraba Forest Steppe

One of the main indisputable results of our study is that the ages of the Andronovo and Late Krotovo cultures are 300–500 yr earlier than previously thought (Table 2). This is in full agreement with the ¹⁴C chronologies of Andronovo culture in neighboring regions (see Table 3).

Table 2 Comparison of traditional and ¹⁴C chronologies for the complexes of the Andronovo period into the Baraba forest steppe.

| Culture | Traditional dating (centuries BC) | ¹⁴ C dating (centuries BC) |
|----------------------|-----------------------------------|---------------------------------------|
| Late Krotovo | 12–14 | 17–19 |
| Andronovo (Fedorovo) | 12–13 | 15–18 |
| Mixed Andronovo | — | 15–17 |

Table 3 Chronology of the Andronovo cultural complex in northern Asia.

| Region | ¹⁴ C dates (centuries BC) | Reference |
|--------------------------------|--------------------------------------|-------------------------|
| Southern Urals | 15–18 | Hanks et al. 2007 |
| Northern Kazakhstan | 17–18 | Panyushkina et al. 2008 |
| Minusinsk Basin, Yenisei River | 15–19 | Svyatko et al. 2009 |
| Baraba forest steppe | 15–18 | This study |

Dating of archaeological complexes in the Baraba forest steppe that follow the Andronovo culture confirms the trend toward older dates. The ¹⁴C dates recently obtained for the Irmen culture of the Late Bronze Age in Baraba region define its lower boundary as the 13–14th centuries BC (Schnee-weiß 2007; Molodin and Parzinger 2009). Thus, the age of the younger cultural complex (Irmen) also became older. Our data indicate the 15th century BC as the upper chronological limit for the Andronovo period. It would be useful to conduct ¹⁴C dating of pre-Andronovo complexes in the near future.

CONCLUSION

Series of ¹⁴C dates for the Late Krotovo culture at the Tartas 1 site were confirmed by the results of dating of the same complex at the Sopka 2/5 site. Because the preservation of bone collagen at the

Sopka 2/5 necropolis is worse than at Tartas 1, the standard deviation for Sopka 2/5 dates is larger (G I Zaitseva and N D Burova, personal communication April 2011). Nevertheless, the ^{14}C dates from both sites are comparable and lie within the 17–19th centuries BC. The reason for poor preservation of collagen at Sopka 2/5 is still unclear. The age of the Andronovo complex at the Stary Tartas 4 site, studied using ^{14}C dating of both cremated and non-cremated bones, corresponds to the 15–18th centuries BC. This is consistent with the timing of both the Late Krotovo and Mixed Andronovo graves at the Tartas 1 and Sopka 2/5 necropolises. Therefore, the results of this study unfortunately cannot help us to answer the question about the number of migratory waves and stages of penetration of the Andronovo population from the core area in the south to the northeast (Baraba forest steppe). This is due to the large standard deviation of available ^{14}C values ($\pm 200\text{--}300$ yr). Thus, all cultural processes (import of particular items; migration of Andronovo population and its interaction with indigenous people) cannot be differentiated using current chronological knowledge. An important methodological result is the direct ^{14}C dating of cremated bones, especially at Stary Tartas 4. Here, inhumations are very random and observed only in children's burials, but children's bones are often poorly preserved and are thus not suitable for ^{14}C dating of collagen fraction.

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REFERENCES

- Bronk Ramsey C. 1995. Radiocarbon calibration and analysis of stratigraphy: the OxCal program. *Radiocarbon* 37(2):425–30.
- Bronk Ramsey C. 2001. Development of the radiocarbon calibration program. *Radiocarbon* 43(2A):355–63.
- Chernykh EN. 1992. *Ancient Metallurgy in the USSR: The Early Metal Age*. Cambridge: Cambridge University Press. 335 p.
- Chernykh EN. 2009. Formation of the Eurasian steppe belt cultures viewed through the lens of archaeometallurgy and radiocarbon dating. In: Hanks B, Linduff K, editors. *Social Complexity in Prehistoric Eurasia. Monuments, Metals, and Mobility*. Cambridge: Cambridge University Press. p 115–45.
- Chernykh EN, Kuzminykh SV, Orlovskaya LB. 2004. Ancient metallurgy in northern Asia: from the Urals to the Sayano-Altai. In: Linduff K, editor. *Metallurgy in Ancient Eastern Eurasia from the Urals to the Yellow River*. Lewiston: Edwin Mellen Press. p 15–36.
- Görtsdorf J, Parzinger H, Nagler A. 2001. New radiocarbon dates of the north Asian steppe zone and its consequences for the chronology. *Radiocarbon* 43(2B): 1115–20.
- Görtsdorf J, Parzinger H, Nagler A. 2004. ^{14}C dating of the Siberian steppe zone from Bronze Age to Scythian time. In: Scott EM, Alekseev AY, Zaitseva GI, editors. *Impact of the Environment on the Human Migration in Eurasia*. Dordrecht: Kluwer/Academic Press. p 83–9.
- Gryaznov MP. 1956. *Istoriya Drevnikh Plemen Verkhni Obi* [The History of the Ancient Tribes of the Upper Ob River]. Moscow-Leningrad: Izdatelstvo Akademii Nauk SSSR. 225 p. In Russian.
- Gvozdetzky NA, Mikhailov NI. 1978. *Fizicheskaya Geografiya SSSR. Aziatskaya Chast* [The Physical Geography of the USSR. Asiatic Part]. 3rd edition. Moscow: Mysl Publishing. 512 p. In Russian.
- Hanks BK, Epimakhov AV, Renfrew AC. 2007. Towards a refined chronology for the Bronze Age of the southern Urals, Russia. *Antiquity* 81(312):353–67.
- Koryakova LN, Epimakhov AV. 2007. *The Urals and Western Siberia in the Bronze and Iron Age*. Cambridge: Cambridge University Press. 384 p.
- Kuzmin YV, Orlova LA. 2004. Radiocarbon chronology and environment of woolly mammoth (*Mammuthus primigenius* Blum.) in northern Asia: results and perspectives. *Earth-Science Reviews* 68(1–2):133–69.

- Kuzmin YV, Burr GS, Jull AJT, Sulerzhitsky LD. 2004. AMS ¹⁴C age of the Upper Palaeolithic skeletons from Sungir site, Central Russian Plain. *Nuclear Instruments and Methods in Physics Research B* 223–224: 731–4.
- Kuzmina E. 2007. *Origin of the Indo-Iranians*. Leiden: Brill. 762 p.
- Matveev AV. 1998. *Pervye Andronotsy v Lesakh Zauralya* [The First Andronovo Bearers in the Trans-Uralian Forests]. Novosibirsk: Nauka Publishing. 417 p. In Russian.
- Molodin VI. 1985. *Baraba v Epokhu Bronzy* [The Baraba Region in the Bronze Age]. Novosibirsk: Nauka Publishing. 200 p. In Russian.
- Molodin VI. 2001. *Pamyatnik Sopka 2 na Reke Omi. Tom I* [The Sopka 2 Site on the Om River. Volume 1]. Novosibirsk: Izdatelstvo Instituta Arkheologii i Etnografii. 128 p. In Russian.
- Molodin VI, Parzinger H. 2009. Khronologiya pamyatnika Chicha-1 [The chronology of the Chicha-1 site]. In: Molodin VI, Parzinger H, editors. *Chicha 1 – Gorodische Perekhodnogo ot Bronzy k Zhelezu Vremeni v Barabinskoy Lesostepi*. Novosibirsk-Berlin: Izdatelstvo Instituta Arkheologii i Etnografii. p 51–77. In Russian.
- Molodin VI, Novikov AV, Zhemerikin RV. 2002. Staryi Tartas-4 burial ground: new data on the Andronovo culture. *Archaeology, Ethnology & Anthropology of Eurasia* 3(11):48–62.
- Molodin VI, Parzinger H, Marchenko ZV, Piezonka H, Orlova LA, Kuzmin YV, Grishin AE. 2008. Pervye radiouglerodnye daty pogrebeniy epokhi bronzy mogilnika Tartas 1 v 2007 godu (popytka osmysleniya) [The first radiocarbon dates of the Bronze Age burials at Tartas 1 site (attempt of comprehension)]. In: Derevianko AP, Makarov NA, editors. *Trudy II (XVIII) Vserossiyskogo Arkheologicheskogo Syezda v Suzdale. Tom I*. Moscow: Institut Arkheologii. p 325–8. In Russian.
- Molodin VI, Mylnikova LN, Novikova OI, Soloviev AI, Nagler A, Durakov IA, Efremova NS, Kobeleva LS, Nenakhov DA. 2009. Etnokulturnye protsessy u naseleeniya tsentralnoy Baraby v epokhu razvitoi bronzy (po materialam issledovaniy mogilnika Tartas 1 v 2009 godu) [The ethnocultural processes among the population of central Baraba forest steppe in the Middle Bronze Age (by materials from the burial ground Tartas 1 in 2009)]. In: Derevianko AP, Molodin VI, editors. *Problemy Arkheologii, Etnografii, Antropologii Sibiri i Sopredelnykh Territoriy. Tom XV*. Novosibirsk: Izdatelstvo Instituta Arkheologii i Etnografii. p 337–42. In Russian.
- Panyushkina IP, Mills BJ, Usmanova ER, Li C. 2008. Calendar age of Lisakovsky timbers attributed to Andronovo community of Bronze Age of Eurasia. *Radiocarbon* 50(3):459–69.
- Potemkina TM. 1985. *Bronzoviy Vek Lesostepnogo Pri-tobolya* [The Bronze Age of Forest Steppe in Tobol River Basin]. Moscow: Nauka Publishing. 376 p. In Russian.
- Reimer PJ, Baillie MGL, Bard E, Bayliss A, Beck JW, Bertrand CJH, Blackwell PG, Buck CE, Burr GS, Cutler KB, Damon PE, Edwards RL, Fairbanks RG, Friedrich M, Guilderson TP, Hogg AG, Hughen KA, Kromer B, McCormac G, Manning S, Bronk Ramsey C, Reimer RW, Remmele S, Southon JR, Stuiver M, Talamo S, Taylor FW, van der Plicht J, Weyhenmeyer CE. 2004. IntCal04 terrestrial radiocarbon age calibration, 0–26 cal kyr BP. *Radiocarbon* 46(3):1029–58.
- Salnikov KV. 1967. *Oherki Drevney Istorii Yuzhnogo Urala* [Essays on Ancient History of the Southern Urals]. Moscow: Nauka Publishing. 408 p. In Russian.
- Schneeweiß J. 2007. *Die Siedlung Čiča in der westsibirischen Waldsteppe I. Untersuchungen zur spät-bronze- bis früheisenzeitlichen Keramik, Chronologie und kulturellen Stellung*. Mainz: Philipp von Zabern Verlag. 422 p.
- Shishlina NI, van der Plicht J, Hedges REM, Zazovskaya EP, Sevastyanov VS, Chichagova OA. 2007. The Catacomb cultures of the north-west Caspian Steppe: ¹⁴C chronology, reservoir effect, and paleodiet. *Radiocarbon* 49(2):713–26.
- Svyatko SV, Mallory JP, Murphy EM, Polyakov AV, Reimer PJ, Schulting RJ. 2009. New radiocarbon dates and a review of the chronology of prehistoric populations from the Minusinsk Basin, southern Siberia, Russia. *Radiocarbon* 51(1):243–73.
- Teploukhov SA. 1927. Drevnie pogrebenia v Minusinskom kraye [The ancient burials in Minusinsk Region]. In: *Materialy po Etnografii. Tom 3, Seriya 2*. Leningrad: Russky Muzei. p 57–112. In Russian.
- Tishkov A. 2002. Boreal forests. In: Shahgedanova M, editor. *The Physical Geography of Northern Eurasia*. New York: Oxford University Press. p 216–33.
- Tkacheva NA, Tkachev AA. 2008. *Epokha Bronzy Verkhnego Priirtyshya* [The Bronze Age of Upper Irtysh River Basin]. Novosibirsk: Nauka Publishing. 304 p. In Russian.
- Van Strydonck M, Boudin M, De Mulder G. 2009. ¹⁴C dating of cremated bones: the issue of sample contamination. *Radiocarbon* 51(2):553–68.
- Zdanovich GB. 1988. *Bronzoviy Vek Uralo-Kazhskikh Stepei (Osnovy Periodizatsii)* [The Bronze Age of Ural-Kazakh Steppes (Basics of Periodization)]. Sverdlovsk: Uralsky Gosudarstvennyy Universitet. 184 p. In Russian.
- Zdanovich GB, Zdanovich DG. 2002. The “country of towns” of southern Trans-Urals. In: Boyle K, Renfrew C, Levine M, editors. *Ancient Interactions: East and West in Eurasia*. Cambridge: MacDonald Institute for Archaeological Research. p 249–64.