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# The Eneolithic Khvalynsk I cemetery: new radiocarbon dates and verification of its general chronology

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## Abstract

This study reports on the new radiocarbon AMS dates obtained on the items made of the animal bones which have been found at Khvalynsk I and provides results of the comparative analysis of these data and the radiocarbon age of the humans. The study provides an opportunity to verify the general chronology of the Volga Khvalynsk I and Khvalynsk II cemeteries and offers the intervals based on the radiocarbon age of the terrestrial samples not influenced by the reservoir effect. The comparative analysis of the data on the isotopic composition of the bone tissue from the individuals and herbivorous animals confirms that aquatic food components accounted for a high share of food consumed by the individuals buried at the Khvalynsk cemeteries. The early stage of the Khvalynsk cemeteries occupation can be set at 4426–4350 BC (1σ) or 4508–4340 BC (2σ). The final stage falls within 4334–4249 BC (1σ) or 4346–4171 BC (2σ). The chronology of these cemeteries is of tremendous significance for the periodization of the Eneolithic cultures of the steppe and forest-steppe Volga regions and their chronological relations as well as the analysis of the chronology within the Khvalynsk contexts, which go far beyond the localities of the Khvalynsk cemeteries. New chronological markers of these two cemeteries are also relevant for comparative chronological analysis of the Eneolithic populations that inhabited the Dnieper region, the Don region, the northern Caucasus and the Caspian region.

Keywords: Eneolithic Khvalynsk I and II cemeteries, verification of radiocarbon chronology, stable isotopes of $\delta^{13}C$ and $\delta^{15}N$

## 18.1 Introduction

Khvalynsk I and Khvalynsk II are the most important cemeteries of the Eneolithic period in Eurasia. They are located on the Lower Volga in the Saratov Region and are characterized by a distinctive funerary rite and grave offerings that include stone hammers and scepters, clay vessels, jewellery made from bone and shells and the largest assemblage of copper items (Agapov et al. 1990; Chernykh & Orlovskaya 2010; Pestrikova & Agapov 2010; Anthony et al. 2022).

The chronology of the Khvalynsk cemeteries on the Volga is important in the context of the studies of the contacts between the Eurasian steppe regions and the metallurgical centres of the Carpatho-Balkan Metallurgical Province (Chernykh & Orlovskaya 2004). E. N. Chernykh believed that the metal from these cemeteries was linked to the Carpatho-Balkan Metallurgical Province of the Copper Age (Chernykh & Orlovskaya 2010). It is of tremendous significance for periodization of the Eneolithic cultures of the steppe and forest-steppe Volga regions and their chronological relations (Korolev & Shalapinin 2014). Materials from the Khvalynsk cemeteries are also important for the analysis of aDNA of the humans buried at these cemeteries.

The first radiocarbon dates were obtained on the human bones and shell beads from the Khvalynsk I graves (Agapov et al. 1990: Table 5). However, it was immediately observed that, most likely, a bone from Skeleton 13 from Khvalynsk I yielded a younger date while the dates on the shell beads were questionable because of a small weight of the samples. Besides, it was assumed that the beads were, possibly, made from fossil shells (Agapov et al. 1990: 86). Over more than 25 years, samples were selected both from Khvalynsk I and

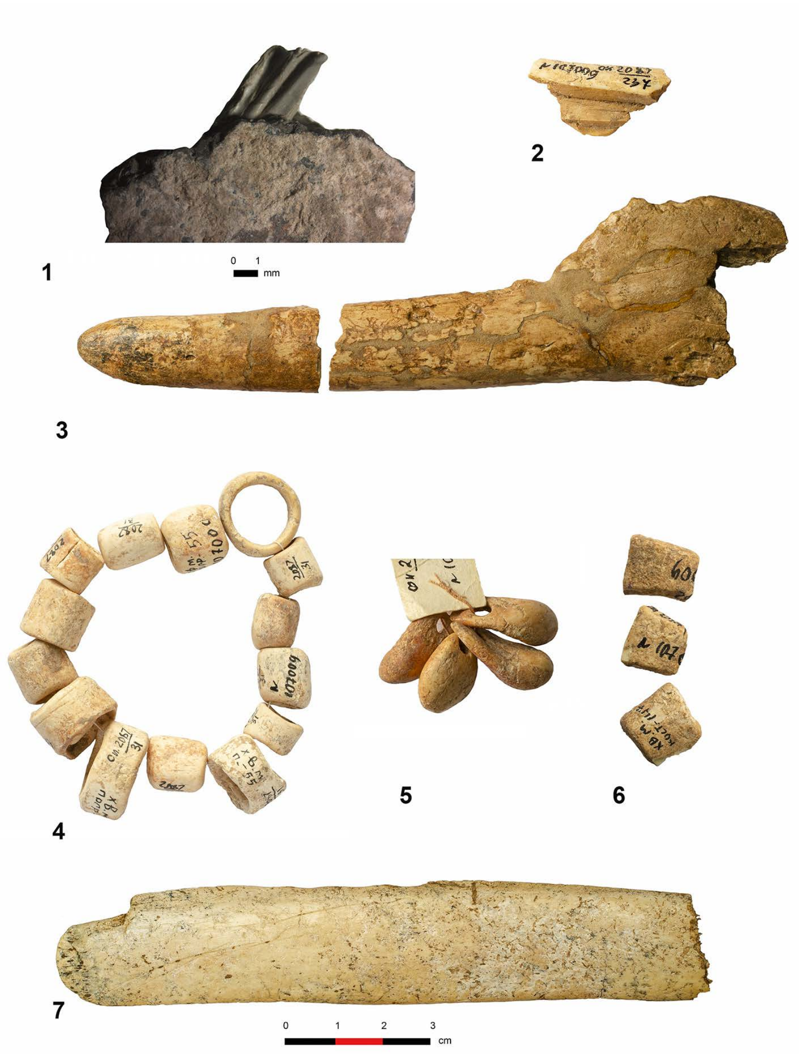


Figure 1. Khvalynsk I: 1 – ceramic fragment with a fish bone, settlement layer; 2 – fragment of a wild boar tusk, Skeletons 147/148; 3 – bone item, Skeleton 24; 4 – bone rings, Skeleton 55; 5 – teeth of a deer, Skeleton 75; 6 – bone bead, Skeleton 148; 7 – bone knife. Photos State Historical Museum, Moscow.

Khvalynsk II for radiocarbon dating, with the results analysed and various chronological intervals proposed such as 5500–4700 calBC, 5000–4500 calBC, 5000–4300 calBC, 5030–4550 calBC, 5250–4550 calBC, 5300–3900 calBC (95.4%) (Trifonov 2001; Chernykh & Orlovskaya 2004; 2010; Korolev & Shalapinin 2014; Korolev & Stavitskiy 2021).

In 2005 we launched a project using the dated carbon-containing samples from the Khvalynsk I assemblage, which includes items made from animal bones (collections of the State Historical Museum in Moscow, SHM). Its aim was to verify the cemetery chronology based on the radiocarbon dates calculated on shells and human bones. $^{14}C$ age of an item made from bone retrieved from Grave 127 (Fig. 1:3) turned out to be pretty much the same as that of the human bones from Graves 10 and 24 at Khvalynsk II. The stable isotope composition of the bone the item was made from ($\delta^{13}C$=-20.7‰ and $\delta^{15}N$=14.6‰) was also practically the same as the stable isotope composition of the humans buried at Khvalynsk I and Khvalynsk II (Shishlina 2008). The high value of $\delta^{15}N$ suggests that the item was made from the bone of a consumer the dietary intake of which had a high percentage of aquatic food. We assume that it was the bone of a dog which consumed some components of human diet (Losey et al. 2013). Follow-up studies need to be performed for more accurate conclusions. Because of these food components, the dog bone, most likely, shows the apparent age, which is the same as the radiocarbon age of the individuals buried at Khvalynsk I and II. The second date obtained on the bone of a wild boar tusk[1] (Fig. 1:2) lying near Skeletons 147/148 turned out to be 300–350 years younger than the radiocarbon dates on the human bones and the shells from Khvalynsk I and II. The isotopic composition of the bone tissue of this sample ($\delta^{13}C$=-17.9‰ and $\delta^{15}N$=11.6‰) differs from that of the bone tissue of the individuals buried at the cemeteries, although it shows elevated values of both carbon and nitrogen isotopes. Wild boars are omnivore animals, they feed on plants; however, their food can include animal matter (Tsarev 2011), which could be reflected in the isotopic composition of the wild boar, different from that of herbivorous animals.

1 Repeated archaeozoological analysis of the SHM Khvalynsk I cemetery collection helped clarify that the fragment dated was from a wild boar tusk rather than a sheep bone.

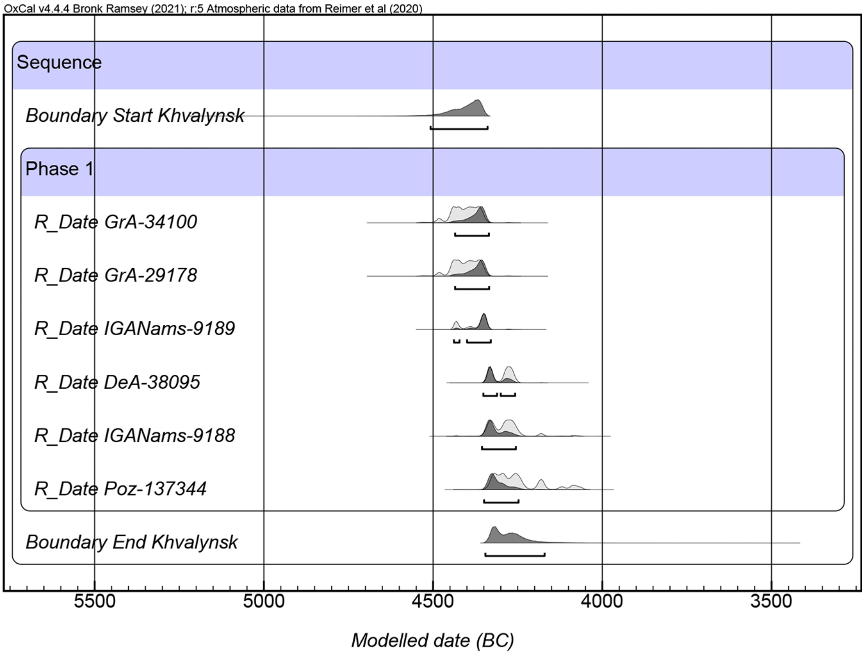


Figure 2. Khvalynsk I and II: summary of the modelled radiocarbon dates of the animal bones.

The new data suggested that a freshwater reservoir correction should be applied to the human bones retrieved from the cemeteries and selected for radiocarbon dating (ΔR=300–350 years). Based on the data analysed, the proposed chronological interval for Khvalynsk I was 4400–4300 calBC (Shishlina 2008). Shortly afterwards parallel dating of various carbon-containing samples such as a human bone and a cow bone (*Bos taurus*) from Grave 10 at Khvalynsk II was performed under the same project. The human bone was 220±45 $^{14}C$ years older than the cow bone because the radiocarbon age of the human was affected by a reservoir effect (Shishlina et al. 2009).

Since spine bones of catfish (*Siluridae*) were found among the materials at the Khvalynsk cemeteries, fish bones were identified in the temper of clay vessels (Fig. 1:1) and the grave offerings included fish hooks and harpoons, there is no doubt that the local people were engaged in fishing as part of their economic strategy. Besides, the isotopic composition of the bone tissue from the individuals buried at Khvalynsk I and Khvalynsk II (Shishlina 2007; 2008; Anthony et al. 2022) also confirms that aquatic foods, for example, fish, accounted for a larger share in the Khvalynsk population dietary intake; it means that the radiocarbon dates on the humans were older because of the freshwater reservoir effect. As an illustration, we can provide the radiocarbon date for a sample of perch (*Perca fluviatilis*) caught in the lower Volga in 1915 (collection of the Moscow State University Zoological Museum) which is about 1200 $^{14}C$ years older (Plicht et al. 2016).

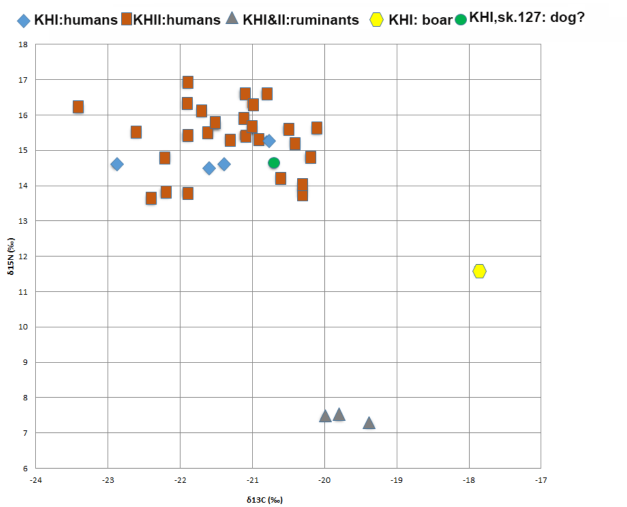


Figure 3. Plot of the results of the $\delta^{13}C$ and $\delta^{15}N$ measurements from Khvalynsk I and II.

The older dates obtained on the shells were also confirmed by additional radiocarbon dating (Kirillova et al. 2018: Table 2). For example, the dates on the *Glycymeris, Scaphopoda, Serpulidae* fossil shells lying near Skeletons 21 and 104 that were found among grave offerings in the Khvalynsk I assemblages fell within 43,960–42,550 calBC. The radiocarbon age of the pendant made from a Unio river shell found at Khvalynsk I is 6200–6050 calBC, which is also older than the date obtained for the wild boar tusk and the cow bone from Khvalynsk I and II.

A recently published paper describing various characteristics of both cemeteries has provided 28 new radiocarbon dates of human bones from Khvalynsk I (4) and Khvalynsk II (24) and discussed paired dated samples (Anthony et al. 2022). The new human-fauna pair included a wild boar tusk and a human female bone buried with this item from Grave 147 at Khvalynsk I. The second dated pair which has been mentioned earlier consisted of the human and the cow bones from Grave 10 at Khvalynsk II. One of the authors of the publication points out that, most likely, the older dates of the human bones have been caused by a reservoir effect and proposes a general chronology of the cemeteries in question corrected for the reservoir effect based on human-fauna dating of these two pairs of samples.

However, some Russian scholars believe that the radiocarbon dates on humans should be taken into account when the chronology of Khvalynsk I and Khvalynsk II is analysed and refined[2] while other scholars rely on the dataset of the radiocarbon data obtained on ceramic fragments that only blurs the chronological limits of Khvalynsk I and Khvalynsk II (Korolev & Shalapinin 2014). Hence, the chronology of the Khvalynsk cemeteries remains highly relevant. The aim of this paper is to discuss new radiocarbon dates on the items made from the animal bones found at Khvalynsk I, to perform comparative analysis of the new dates and radiocarbon age of the humans and to verify general chronology of Khvalynsk I and Khvalynsk II.

2 A presentation by D. Anthony, A. Khokhlov, S. Agapov, D. Agapov, R. Schulting and I. Olalde on 'The Khvalynsk Eneolithic cemetery on the Volga (archaeology, radiocarbon dating, anthropology and paleogenetics)' in the Bronze Age Department of the Institute of Archaeology, RAS, on April 28, 2022.

# 18.2 Materials and methods

During the new stage of the chronology verification project implemented in 2021, seven samples were selected from seven graves of Khvalynsk I for AMS dating: fragments of the items made from animal bones found on or near Skeletons 10, 47, 55, 75, 97, 147 and 148 (Fig. 1:4–7). Two samples did not have collagen. Other two samples were dated in the Institute of Geography, RAS (Russia), together with the University of Georgia (USA); one sample was dated in the Poznan Radiocarbon Laboratory (Poland), and the remaining sample was dated in the Isotoptech Zrt., Debrecen (Hungary). Radiocarbon data obtained were calibrated with the OxCal software v4.4 (Bronk Ramsey 2017) and the IntCal20 calibration curve (Reimer et al. 2020).

To estimate the period when Khvalynsk I and Khvalynsk II were used, it was necessary to develop a chronological model based on the sequence of the dates which were calculated on animal bones. To this end, a Bayesian model was constructed, placing the data into the phase (using the Phase command in OxCal v4.3.2). The Start and End boundaries were determined using the values of the boundary medians (Boundary command; Bronk Ramsey 2017).

# 18.3 Results and discussion

The results of AMS dating are shown in Table 1 and Figure 2 along with the earlier published $^{14}C$ dates (Shishlina 2008: 202, 284). There is significant difference between the radiocarbon dates obtained on the animal bones and the dates on the human bones (Anthony et al. 2022: Table 1). Based on the paired human-fauna dating mentioned earlier, the bones of the herbivorous animals show that the human bones are on average 401±288 years older (Anthony et al. 2022). The isotopic compositions of the herbivorous animals (the ungulate, the deer and the cow; mean $\delta^{13}C$=-19.72±0.26‰; $\delta^{15}N$=7.43±0,10 ‰) also differ from those of the buried humans (Fig. 3). During earlier

| Site | No | Lab ID | Material | Context | BP | calBC probability [start:end] | $\delta^{13}C$, ‰ VPDB | $\delta^{15}N$,‰ AIR | C:N |
|---|---|---|---|---|---|---|---|---|---|
| Khvalynsk I | 1 | DeA-38095 | Fragment of a ring from ungulate bone | Skeleton 55 | 5446±24 | 68.3%<br>4340 (24.3%) 4323<br>4290 (43.9%) 4262<br>95.4%<br>4348 (36.1%) 4312<br>4302 (59.3%) 4251 | - | - | - |
| | 2 | $IGAN_{ams}$-9188 | Knife made from animal/ungulate bone | Skeleton 97 | 5440±30 | 68.3%<br>4338 (21.7%) 4322<br>4293 (46.6%) 4259<br>95.4%<br>4348 (95.4%) 4248 | -19.80 | 7.5 | 3.1 |
| | 3 | $IGAN_{ams}$-9189 | Tooth of red deer (*Cervus elaphus*)* | Skeleton 75 | 5520±25 | 68.3%<br>4440 (17.1%) 4424<br>4366 (51.2%) 4338<br>95.4%<br>4445 (23.9%) 4414<br>4406 (71.6%) 4332 | -19.37 | 7.3 | 3.1 |
| | 4 | Poz-137344 | Flattened bead made from diaphysis of a large tubular bone of a medium-sized mammal* | Skeleton 148 | 5400±40 | 68.3%<br>4341 (23.7%) 4318<br>4296 (44.5%) 4256<br>95.4%<br>4358 (92.4%) 4234<br>4191 (3.1%) 4172 | - | - | - |
| | 5 | GrA-29178 | Fragment of a wild boar tusk (*Sus scrofa refus*) | Skeleton 147/148 | 5565±40 | 68.3%<br>4444 (25.0%) 4417<br>4404 (43.3%) 4356<br>95.4%<br>4488 (2.5%) 4476<br>4458 (93.0%) 4341 | -17.86 | 11.6 | 3.3 |
| Khvalynsk II | 6 | GrA-34100 | Cow (*Bos taurus*) bone* | Grave 10 | 5570±40 | 68.3%<br>4445 (25.6%) 4416<br>4406 (42.7%) 4358<br>95.4%<br>4491 (3.8%) 4472<br>4460 (91.6%) 4342 | -20.00 | 7.5 | 3.3 |

Table 1. Results of $^{14}C$ AMS datings of the animal bones from Khvalynsk I and II; * – determination by I. V. Kirillova, 2010.

studies, the data obtained on additional materials from the Khvalynsk II and Lebyazhinka V sites on the Volga ($\delta^{13}C$=-21.5±1.0‰ and $\delta^{15}N$=14.3±0.9‰) proved that the diet system of the Middle Volga population had several components, including fish (Schulting & Richards 2016).

The comparative analysis of the stable isotope data on the human and herbivore bones shows that the data on the humans (Anthony et al. 2022) and the herbivore animals are plotted in different regions (Fig. 3). The isotopic composition of the sampled bone item, most likely, made from a dog bone, which was found on Skeleton 127, coincides with the isotopic composition of the humans. The same result was obtained by the stable isotope analysis of bone tissue of human and dog bones from other sites in Eurasia (Losey et al. 2013). Presumably, food intake of the dogs consisted of food scraps including aquatic food. The isotopic composition of the wild boar tusk is plotted in a separate region on the plot as well (Fig. 3). These data indicate that, most likely, aquatic foods accounted for a significant share of the dietary intake of the individuals and that the meat of herbivore animals was consumed in much smaller quantities compared to aquatic foods, at least, by the Khvalynsk individuals. Unfortunately, there is no available data on fish bones from the Khvalynsk cemeteries; therefore, they cannot be used in comparative analysis. However, the radiocarbon age of all human bones from Khvalynsk I and II is much older than the radiocarbon age of the items made from animal bones put in the graves. It means that the dates on the human bones are older because of the reservoir effect caused by consumption of aquatic food by the buried humans (Plicht et al. 2016).

## 18.4 Conclusion

The results of the new project (2021–2022) on radiocarbon dating of the items made from the animal bones found in the human graves at Khvalynsk I and the analysis of the data published earlier provided an opportunity to verify chronology of Khvalynsk I and Khvalynsk II as well as propose the intervals based only on radiocarbon age of the terrestrial samples not affected by reservoir affects.

The one-phase model was used to calculate the range of the calibrated radiocarbon dates that determine the time span during which the Khvalynsk cemeteries were used (Start, End). The early stage of the Khvalynsk cemeteries occupation can be set at 4426–4350 calBC (1σ) or 4508–4340 calBC (2σ). The final stage falls within 4334–4249 calBC (1σ) or 4346–4171 calBC (2σ). These intervals are consistent with the proposed interval of 140 years at 28 years/generation, which means family graves within roughly five generations of relatives buried at Khvalynsk II (Anthony et al. 2022). The estimated interval confirms the earlier suggestion on the likely time boundaries of the Khvalynsk I and Khvalynsk II occupation. The interval is based only on one pair of synchronous dates, i.e. 4400–4300 calBC (Shishlina 2008). The new phase shows again that all dates calculated on the human bones are older because of the reservoir effect.

These chronological intervals are very important for discussing the chronology within the Khvalynsk contexts, which go far beyond the localities of the Khvalynsk cemeteries because the sites left by the Khvalynsk population in other regions may be dated to an earlier period (Vybornov et al. 2021). New chronological markers of these two cemeteries are also relevant for comparative chronological analysis of the Eneolithic populations that inhabited the Dnieper region, the Don region, the northern Caucasus and the Caspian region. The new data on the nitrogen and carbon isotopic composition of ruminants/herbivore animals are also important for follow-up studies aimed to clarify the diet system of the individuals buried at the Khvalynsk cemeteries.

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