Radiocarbon (2024), pp. 1–15
doi:10.1017/RDC.2024.40

CAMBRIDGE UNIVERSITY PRESS

RESEARCH ARTICLE

Barrow Necropolis from the 3rd and 2nd Millennia BC in Western Ukraine. A Bayesian Modeling and Isotopic Study

Przemysław Makarowicz[1], Tomasz Goslar[2,3], Anita Szczepanek[4,5], Maryna Yahodynska[6], Vasyl Ilchyshyn[7], Aleksandra Kozak[8], Jan Romaniszyn[1], Jakub Niebieszczański[1], Vitalii Rud[9] and Łukasz Pospieszny[10,11]

[1]Faculty of Archaeology, Adam Mickiewicz University in Poznań, Uniwersytetu Poznańskiego 7, 61-614 Poznań, Poland, [2]Faculty of Physics, Adam Mickiewicz University in Poznań, Uniwersytetu Poznańskiego 2, 61-614 Poznań, Poland, [3]Poznań Radiocarbon Laboratory, Poznań Park of Science and Technology, Rubież 46, 61-612 Poznań, Poland, [4]Institute of Archaeology and Ethnology, Polish Academy of Sciences, Sławkowska 17, 31-016 Kraków, Poland, [5]Department of Anatomy, Jagiellonian University, Collegium Medicum, Kopernika 12, 31-034 Kraków, Poland, [6]Ternopil Regional Center for the Protection and Research of Cultural Heritage Sites, Kyivska 3a, Ternopil, 46003, Ukraine, [7]Kremenetsko-Pochaivskii Derzhavnyi Istoriko-arkhitekturnyi Zapovidnik, 47003 Kremenets, Kozubskogo 6, Ukraine, [8]Bioarchaeology Department, Institute of Archaeology National Academy of Science of Ukraine, Volodymyr Ivasiuk av., 12 Kyiv, Ukraine, [9]National Academy of Sciences of Ukraine, Institute of Archaeology, Kyiv, Ukraine, Volodymyr Ivasiuk av. 12, 04210 Kyiv, Ukraine, [10]Institute of Archaeology, University of Gdańsk, ul. Bielańska 5, 80-851 Gdańsk, Poland and [11]Department of Anthropology and Archaeology, University of Bristol, 43 Woodland Road, BS8 1UU Bristol, UK

Corresponding author: Przemysław Makarowicz; Email: przemom@amu.edu.pl

Received: 16 August 2023; **Revised:** 05 February 2024; **Accepted:** 17 February 2024

Keywords: AMS dating; barrows; Bayesian modeling; burials; diet

Abstract

This article discusses the absolute chronology of burials from the 3rd and 2nd millennia BC discovered under the mounds of three barrows in the Kordyshiv cemetery in western Ukraine. Its aim is to create a chronological model of the burials by modeling 27 AMS ^{14}C dates obtained from 21 individuals buried in single and collective graves. Dietary analysis of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope values are presented. The Bayesian modeling of the ^{14}C dates from the three Kordyshiv barrows revealed the extremely important role of these monuments as long-term objects used for ritual purposes. At the end of the 3rd millennium BC, the epi-Corded Ware Culture (epi-CWC) community erected a mound over the central burial in Barrow 2, then interred the graves of three additional deceased. After several hundred years Barrow 2 was reused by Komarów Culture (KC) communities from the Middle Bronze Age (MBA) who interred their deceased in the existing mound. The oldest monument with MBA burials was Barrow 3, in which the dead were buried in a two-stage sequence before and after the mid-2nd millennium BC. The youngest dated grave was Burial 1 in Barrow 1, comprising a collective burial that was interred between 1400 and 1200 BC. The additional analyses of carbon and nitrogen isotopes show significant differences in the diet of epi-CWC individuals buried in Barrow 2 from the individuals representing the KC.

Introduction

The upper Dniester basin—a zone on the border between forest-steppe and forest—is an area where several thousand burial mounds from the late Eneolithic and Bronze Age occur. These date more precisely to the 3rd millennium and the first half of the 2nd millennium BC (Sulimirski 1968; Sveshnikov 1974; Machnik et al. 2006, 2011; Makarowicz et al. 2016, 2019). They create vast cemeteries located on river watersheds in the elevated parts of the landscape. In similar barrows from the Black Sea steppe and forest-steppe or from the Carpathian Basin and the Balkans, primary burials (of the builders of the barrows) are positioned under the mounds, while secondary burials are dug into them (e.g., Anthony 2007; Ivanova 2021; Heyd et al. 2021). In contrast, the Upper Dniester monuments were rarely used by subsequent cultures (Sulimirski 1968; Makarowicz et al. 2016, 2018, 2019).

Based on relative dating methods, the older phase of barrow necropolises in the study area is of the Corded Ware culture (CWC) and dates to the Late Eneolithic (2900/2800–2200 BC), while the younger phase is represented by the Komarów culture (KC) of the Middle Bronze Age (1800/1700–1400 BC), which was a local variant of the Trzciniec Cultural Circle (TCC; Makarowicz 2010). In barrow burials, the deceased were buried individually or collectively, and their bodies were sometimes cremated in situ in graves with wooden and wood-stone constructions. The CWC graves were dominated by burials of inhumed individuals, mainly adult males, while the KC graves were used for the burial of the dead of both sexes as well as children, often in groups. Grave goods of various materials were provided for the dead: dishes, ritual food and drinks, hand, leg, and head decorations, and sometimes weapons. Wealth was usually greater in graves from the 2nd millennium BC.

In the borderland between the forest and forest steppe area, the under-barrow architecture from the Middle Bronze Age is more spectacular and includes various stone and wood structures, especially the so-called mortuary houses. In contrast, in the case of the CWC community, simple grave pits lacking additional structures or with wooden constructions such as logs or coffins/timbers are common (Swiesznikow 1967; Sulimirski 1968; Sveshnikov 1974; Romaniszyn 2015; Makarowicz et al. 2016; Romaniszyn and Makarowicz 2021).

The aim of this article is to create a chronological model of the burials from the 3rd and 2nd millennia BC discovered under the mounds of three barrows in the Kordyshiv cemetery, Site VIII, Shumsk District, Tarnopil Province, in western Ukraine. Bayesian modeling of 27 AMS ^{14}C dates obtained for 21 individuals buried in single and collective graves as well as a dietary analysis of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope values are presented. The Bayesian modeling and discussion of the burials and burial mounds in the studied cemetery also considers the archaeological data comprising the analysis of artifacts deposited in the graves.

Archaeological Background

The necropolis in Kordyshiv is located in the northwestern part of the Podolia Upland, almost on the border with the Volhynian Upland, about 15 km east of the Krzemieniec Hills (Ilchyshyn 2016). The cemetery is situated on a flattened part of a promontory, which is a fragment of a hill on the watershed between the Vilia River, about 300 m northwest of its modern course, and 600–700 m southeast of the Shipinka Stream that flows into a small lake (Figure 1). According to reports from the late 19th century, about 20 mounds were still visible in this area at that time (Teodorovich 1983). Contemporary field-walking research has not revealed the indisputable presence of barrows. Only extensive, low "hills" arranged in a linear alignment were visible, marking the places where the three burial mounds were situated.

Archaeological excavations have explored several burials within three clusters that were originally located under the mounds. The presence of mounds may be evidenced by the compact arrangement of graves ("in a circle") and the darker color of the earth within the area of barrow 1. However, the ranges of the barrows could be determined only indicatively, due to the significant degree of destruction caused by deep ploughing in modern times (Figures 2–4).

In Barrow 1, a collective burial of four cremated individuals representing the KC was recorded. ^{14}C dates were obtained only for two of the four individuals (Individuals 3 and 4 from Burial 1) and for the wooden structure of the grave (Table 1). In Barrow 2, four CWC burials (Burials 1, 2, 7, and 8) and a skull between the first two (probably from Individual 2), as well as three KC burials (Burials 5, 6, and 9) were discovered. All Barrow 2 burials excluding Burial 8 have been dated (Table 1). In Barrow 3, five KC burials were documented: Burials 1, 4, 7, and 9 (all double burials) and Burial 2 (a collective burial of six individuals), for which a total of 17 ^{14}C dates were obtained.

The grave goods that accompanied the deceased in the Middle Bronze Age KC were spectacular and comprised numerous bronze items (bracelets, pins for fastening funeral robes), and ceramic vessels

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

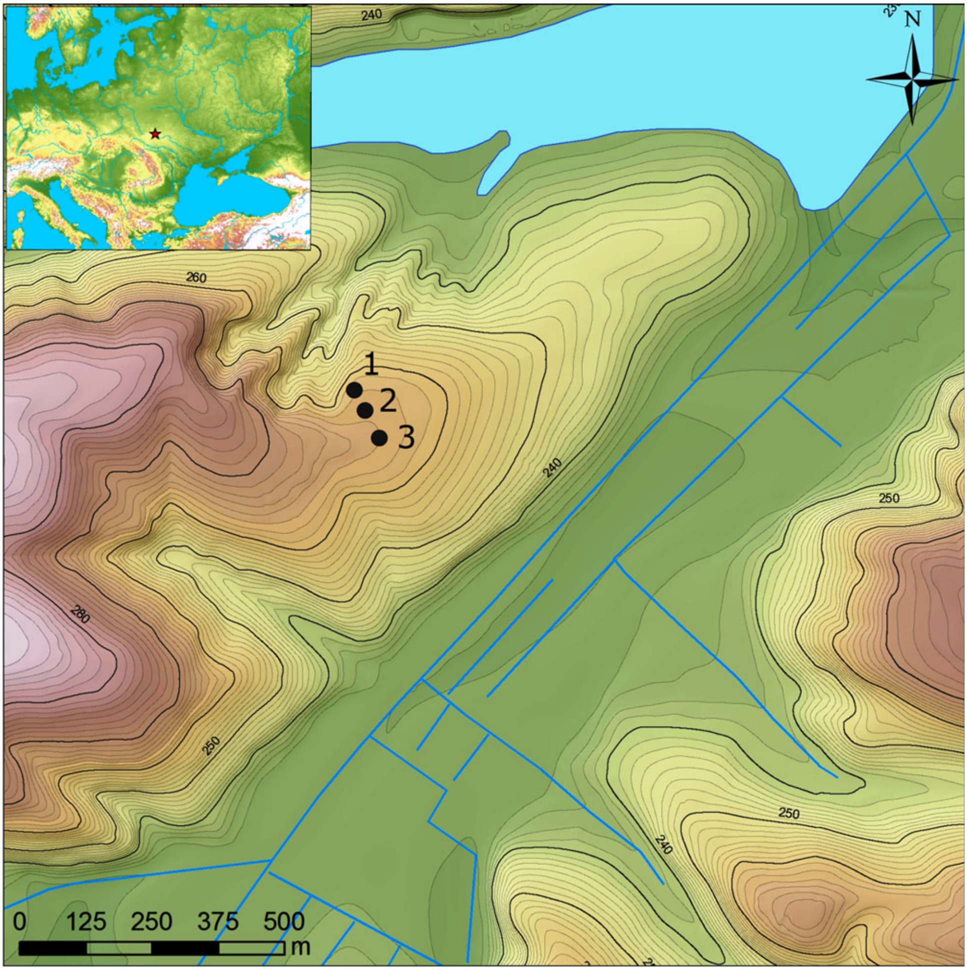

Figure 1. *Location of the barrow cemetery in Kordyshiv, western Ukraine.*

(Ilchyshyn 2016). A preliminary archaeological analysis based on the typo-chronology of several grave goods (a stone axe, fragments of vessels, and flints) indicates the CWC burials date to a later phase of development, generally referred to as late CWC or epi-CWC, while both older and younger assemblages can be distinguished within the periodization of the burials from the KC group (Sulimirski 1968; Makarowicz et al. 2016).

Materials and Methods

Radiocarbon Dating

Radiocarbon dating of materials from the studied monuments in Kordyshiv was performed at the Poznań Radiocarbon Laboratory and included 26 bone samples from 21 human skeletons and 1 sample of charcoal (Table 1). Samples of bone were dated using collagen extracted with the Longin method (1971) supplemented by removal of humic substances in a NaOH solution and ultrafiltration (on Vivaspin® Turbo 15 PES, MWCO 30 kDa) of the extract (Bronk Ramsey et al. 2004; Brock et al. 2010). Good preservation of the extracted collagen samples was indicated by collagen yield and the atomic ratio of C/N (Table 1) that fell within the intervals recommended by van Klinken (1999). Cremated bones, having no collagen preserved, were dated using carbon from structural carbonates

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

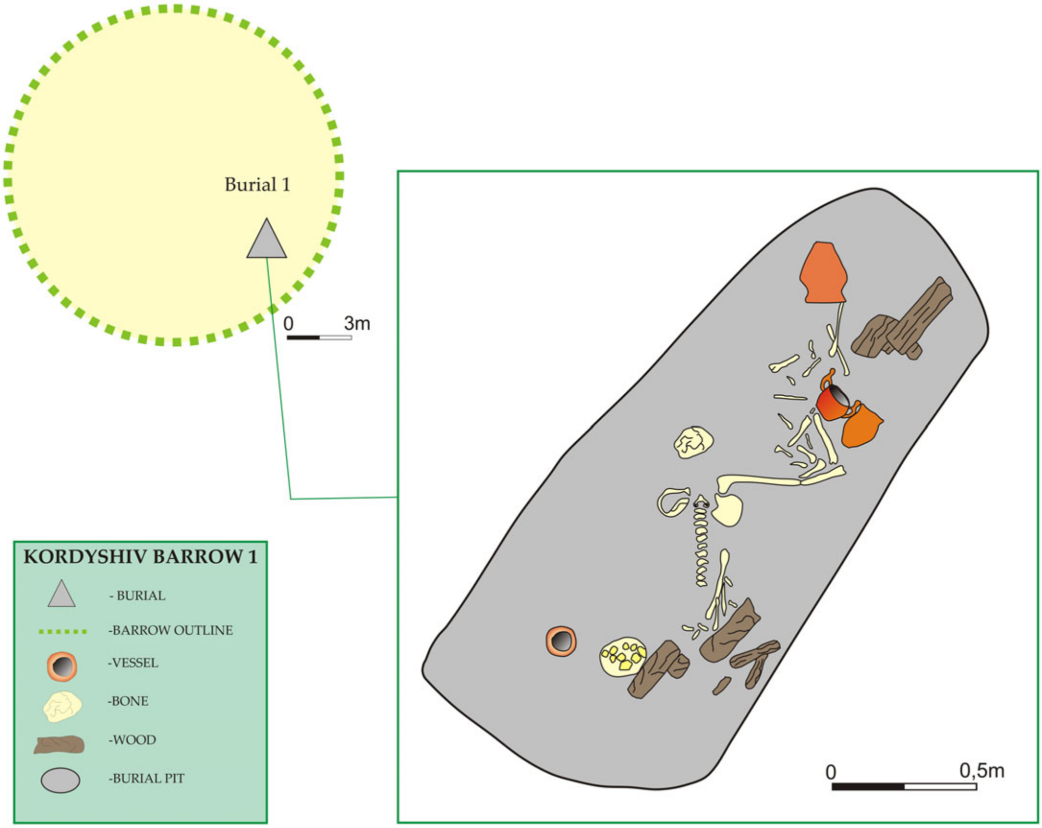

Figure 2. *Kordyshiv. Schematic plan of Barrow 1 and the collective Komarów culture burial from the Middle Bronze Age.*

(apatites), extracted with the procedure of Lanting et al. (2001). For this purpose, only calcined bones white in color, indicating that they were cremated at high temperatures of 800°C or more (Walker et al. 2008), were chosen for analysis.

Portions of CO_2 resulting from the combustion of collagen or decomposition of structural carbonate were graphitized with hydrogen (H_2), and isotopic ratios $^{14}C/^{12}C$ and $^{13}C/^{12}C$ in the graphite were measured with a "Compact Carbon AMS" spectrometer (Goslar et al. 2004).

Recent research on the chronology of long-term funerary architecture, especially megaliths and burial mounds, now incorporate Bayesian modeling of radiocarbon dates. Indeed, this has become one of the key methods for determining the time intervals of burying the dead, the period of grave use, the rate of placing subsequent individuals, and in the case of barrow necropolises, the chronology and order in which individual mounds and their arrangements were erected (e.g., Aranda Jiménez and Lozano Medina 2014; Bourgeois and Fontijn 2015; Aranda Jiménez et al. 2018; Makarowicz et al. 2018, 2021, 2023; Salazar García et al. 2016; Szilágyi et al. 2018; Steuri et al. 2019). As such, radiocarbon ages were calibrated against the INTCAL20 curve (Reimer et al. 2020) and underwent Bayesian analysis performed using OxCal v4.2.3 (Bronk Ramsey 1995, 2009; Bronk Ramsey and Lee 2013).

The radiocarbon calibration also considered the accumulation of carbon in bones, assuming that the ^{14}C level in the bone collagen of a living organism reflects the average concentration of radiocarbon in the atmosphere over its lifespan. According to Geyh (2001), this effect could be corrected for by means of a correction term dependent on the age-at-death of the individual. In the present work, we used the age-at-death-dependent correction terms to *shift* the probability distributions of the calibrated dates, admitting that the magnitude of the shift, unknown exactly, has its own probability distribution. Then,

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

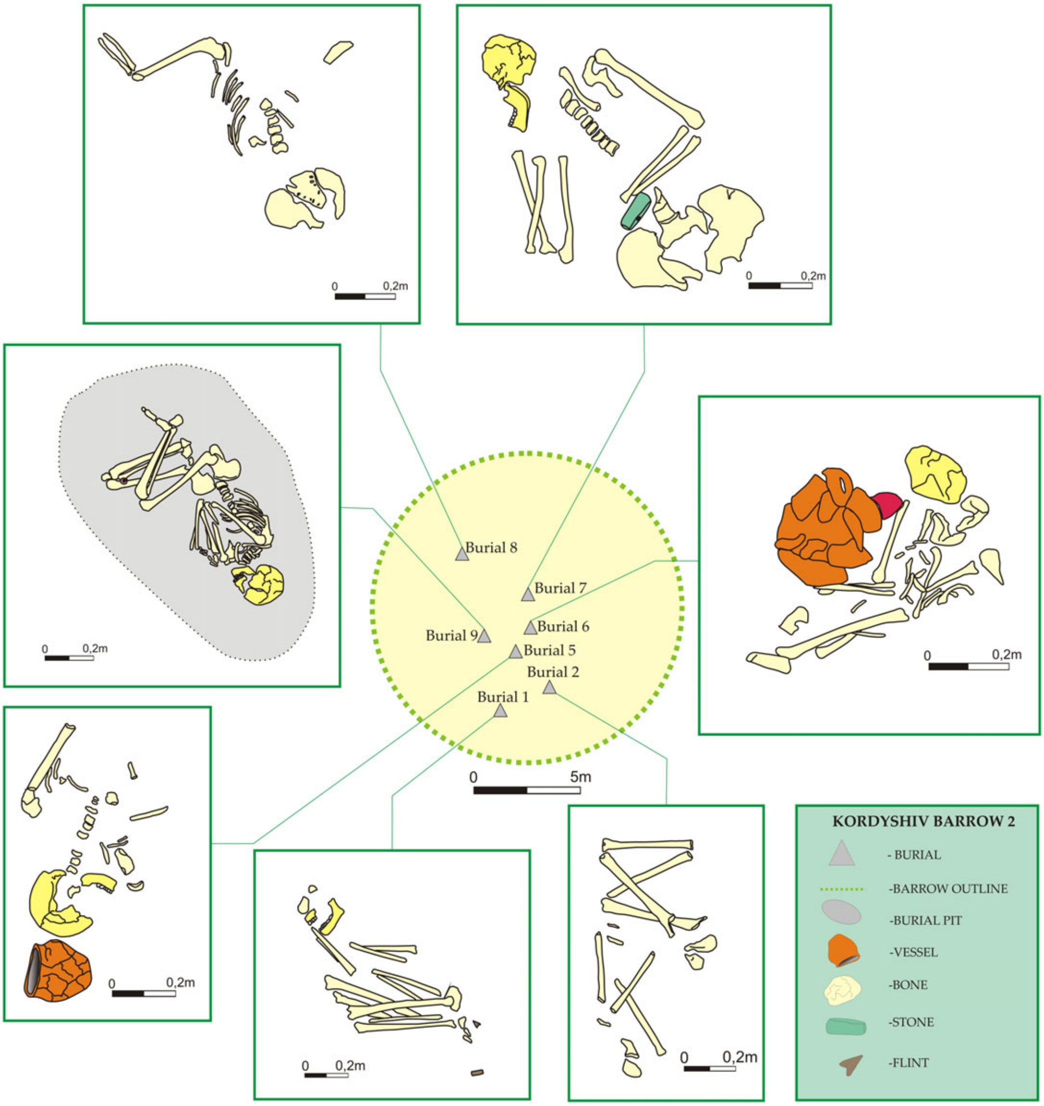

Figure 3. Kordyshiv. Schematic plan of Barrow 2 and the Late Eneolithic epi-Corded Ware culture and Middle Bronze Age Komarów culture burials.

similar to our previous study (Makarowicz et al. 2021), we used one of several normal distributions for each sample, depending on the class of the age-at-death (adultus, maturus, etc., for details see caption to Figure 5). The biological age used for this purpose as well as morphological sex of the deaseased were estimated according to standard methods applied to analyses of inhumed skeletons and cremated remains. Dimorphic morphological features of the skull and pelvis allowed for sex determination (White and Folkens 2005). In the case of cremated bones, larger fragments of the frontal and occipital bones with superciliary arches and external occipital protuberance enabled sex identification (Fairgrieve 2008). Age at death was estimated through registration of changes in the symphyseal faces of the pubic symphysis and in the auricular surfaces of the ilium as well as the degree of cranial suture closure and tooth crown attrition (White and Folkens 2005).

The calibrated date of the only charcoal sample (from Barrow 1, Table 1) was corrected for the "old wood effect" (Schiffer 1986; Makarowicz et al. 2021), that, based on the size of charred fragments

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

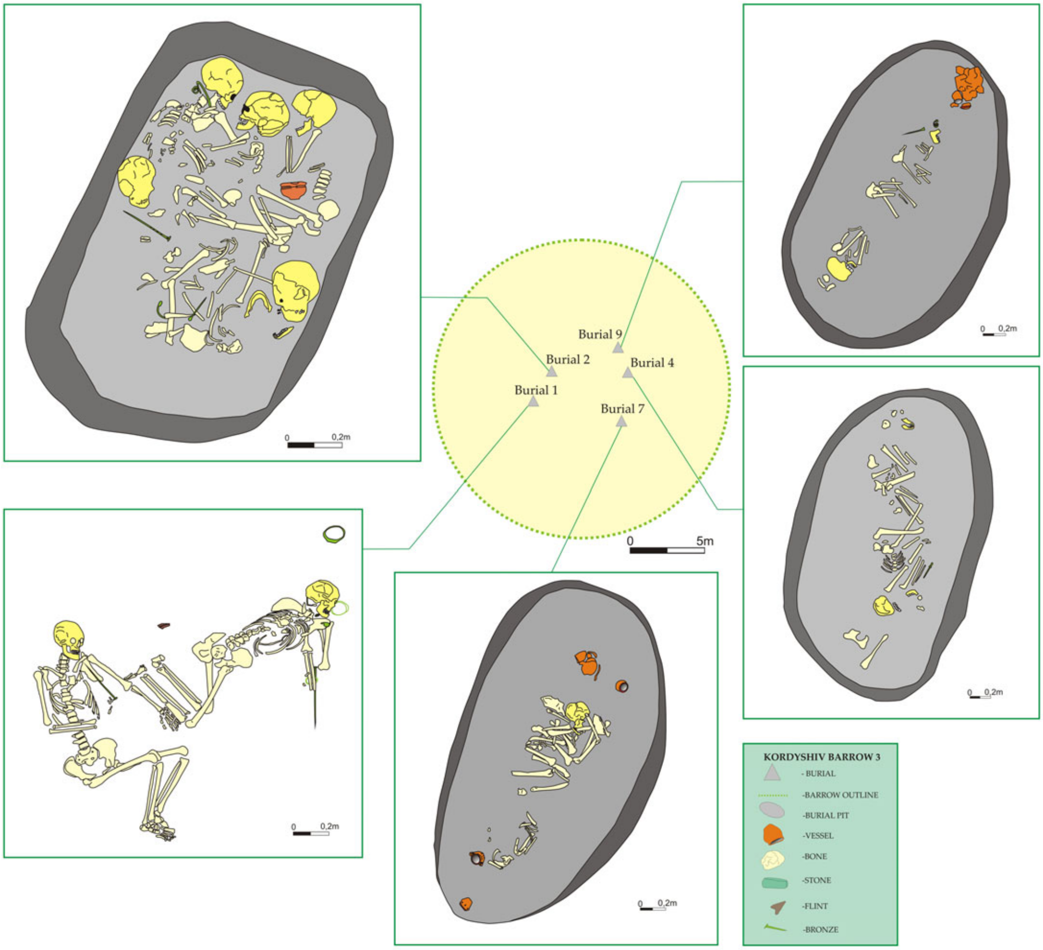

Figure 4. *Kordyshiv. Schematic plan of Barrow 3 and Komarów culture burials from the Middle Bronze Age.*

found, was assumed to be no larger than 30 years (cf. correction "Unk" in Figure 5). A charcoal sample has been taken from a charred wood log (oak)—a structural element of the grave—with a diameter of less than 15 cm (the smallest fragment in the southern part of the grave in Figure 2). As demonstrated by, for example, Zazzo et al. (2012) and Snoeck et al. (2014), ^{14}C ages of cremated bones may also be altered by the partial replacement of its carbonate carbon with that from the fuel used for cremation. Hence, if the fuel in Barrow 1 was wood no older than 30 years, we can argue that its average ^{14}C signature is roughly the same as that in the bones of humans who died at the age of Adultus_Maturus, making the influence of this replaced carbon negligible.

Stable Carbon and Nitrogen Isotope Analyses

Radiocarbon dating was supplemented by analyzing the stable isotopic composition of nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) in collagen extracted from bones that were ^{14}C dated at the Poznań Radiocarbon Laboratory. These data allowed the dietary patterns of the analyzed individuals to be discussed. Specifically, the analysis of $\delta^{13}C$ in human bone collagen enabled the consumption of C_3- vs. C_4-based foods (i.e., most plants compared to millet) to be distinguished (Lee-Thorp 2008; van Klinken et al 2000). Considering that $\delta^{15}N$ values correspond to the trophic levels that organisms hold in the food

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

Table 1. *^{14}C ages of samples collected from the graves described in the text. Values of %coll/C/N$_{at}$ represent collagen extraction yields and atomic C/N ratios measured in collagen*

Barrow/ culture	Burial/ individual	Material	Sex	Age at death	Lab no. Poz-	^{14}C BP	%coll/ C/N$_{at}$	δ^{13}C ‰	δ^{15}N ‰
1/KC	1/-	Charcoal	—	—	134239	3120 ± 30	—	—	—
1/KC	1/3	Burnt bone	?	20–50	140906	3050 ± 30	Carbonate	—	—
1/KC	1/4	Burnt bone	?	20–50	140904	3030 ± 30	Carbonate	—	—
2/CWC	1/1	Bone	M	40–50	142406	3735 ± 35	5.4/3.22	–19.6	10.0
2/CWC	2/1	Bone	M	40–45	140418	3735 ± 35	7.9/3.18	–20.2	10.3
2/CWC	1-2/-	Bone	?	30–50	140422	3720 ± 35	7.7/3.20	–19.6	10.7
2/CWC	7/1	Bone	M	20–25	140419	3855 ± 35	6.6/3.17	–20.2	10.3
2/KC	5/-	Bone	M	40>	154882	3185 ± 35	3.0/3.01	–19.6	9.7
2/KC	6/-	Bone	?	14	154883	3170 ± 35	2.9/2.98	–16.5	10.2
2/KC	9/1	Bone	F	30–35	140420	3080 ± 35	4.5/3.20	–17.6	10.2
3/KC	1/1	Bone	F	35–45	83755	3325 ± 35	6.8/3.26	–19.9	7.8
3/KC	1/2	Bone	F	20–35	83756	3315 ± 35	6.5/3.23	–20.1	7.8
3/KC	1/2	Bone	F	20–35	142481	3275 ± 35	6.7/3.18	–21.2	9.7
3/KC	1/2	Bone	F	20–35	89337	3265 ± 30	4.3/3.13	–20.0	11.3
3/KC	2/1	Bone	?	6–8	133497	3165 ± 30	4.2/3.21	–15.7	10.2
3/KC	2/2	Bone	M?	7–8	133578	3075 ± 35	8.4/3.22	–16.1	10.1
3/KC	2/3	Bone	F	20–25	133579	3165 ± 30	4.6/3.21	–17.0	10.0
3/KC	2/4	Bone	F	5–6	133580	3170 ± 35	4.4/3.21	–14.5	11.5
3/KC	2/5	Bone	M?	9–11	133581	3120 ± 35	6.3/3.19	–13.3	10.4
3/KC	2/6	Bone	?	1–2	133582	3145 ± 35	6.7/3.21	–15.7	9.1
3/KC	4/N	Bone	F?	30–40	142485	3105 ± 35	4.8/3.17	–16.8	10.4
3/KC	4/S	Bone	M	30–35	142486	3095 ± 35	5.1/3.20	–18.1	10.2
3/KC	7/N	Bone	F?	40–50	142475	3080 ± 35	6.6/3.20	–17.8	10.4
3/KC	7/S	Bone	F	35-40	89335	3150 ± 35	14.3/3.07	–15.7	11.3
3/KC	9/N	Bone	F	20–30	142478	3100 ± 35	4.3/3.19	–17.7	10.0
3/KC	9/N	Bone	F	20–30	83757	3155 ± 30	5.0/3.29	–17.8	8.1
3/KC	9/S	Bone	M	30–35	142480	3115 ± 35	4.2/3.21	–19.1	10.4

M—male, F—female.

chain and depend on the animal protein dietary fraction (Hedges, Reynard 2007), these data were also obtained to understand dietary differences across the burials and whether freshwater fish consumption caused a “reservoir effect” to impact the radiocarbon dates (e.g., Cook et al. 2001; Olsen et al. 2010).

Stable isotope ratios (Table 1) were measured with isotope ratio mass spectrometry (IRMS) at the Goethe University in Frankfurt and at the Institute of Geological Sciences, Polish Academy of Sciences, Warsaw using a Thermo Flash EA 1112HT elemental analyzer connected to a Thermo Delta V Advantage IRMS in a Continuous Flow system. The samples were analyzed against the international standards USGS 40, USGS 41, and IAEA 600 with a calculated analytical uncertainty for δ^{13}C and δ^{15}N of ±0.33‰ and ±0.43‰, respectively.

Results and Discussion

Absolute Chronology

Conventional radiocarbon ages of bones can be affected by the reservoir effect if dated individuals relied on the consumption of aquatic products, a habit that would also be reflected in elevated δ^{15}N values in collagen (e.g., Cook et al. 2001; Olsen et al. 2010). The question of such an impact on the dates of burials from the 2nd millennium BC in East Central Europe has been more widely discussed by

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

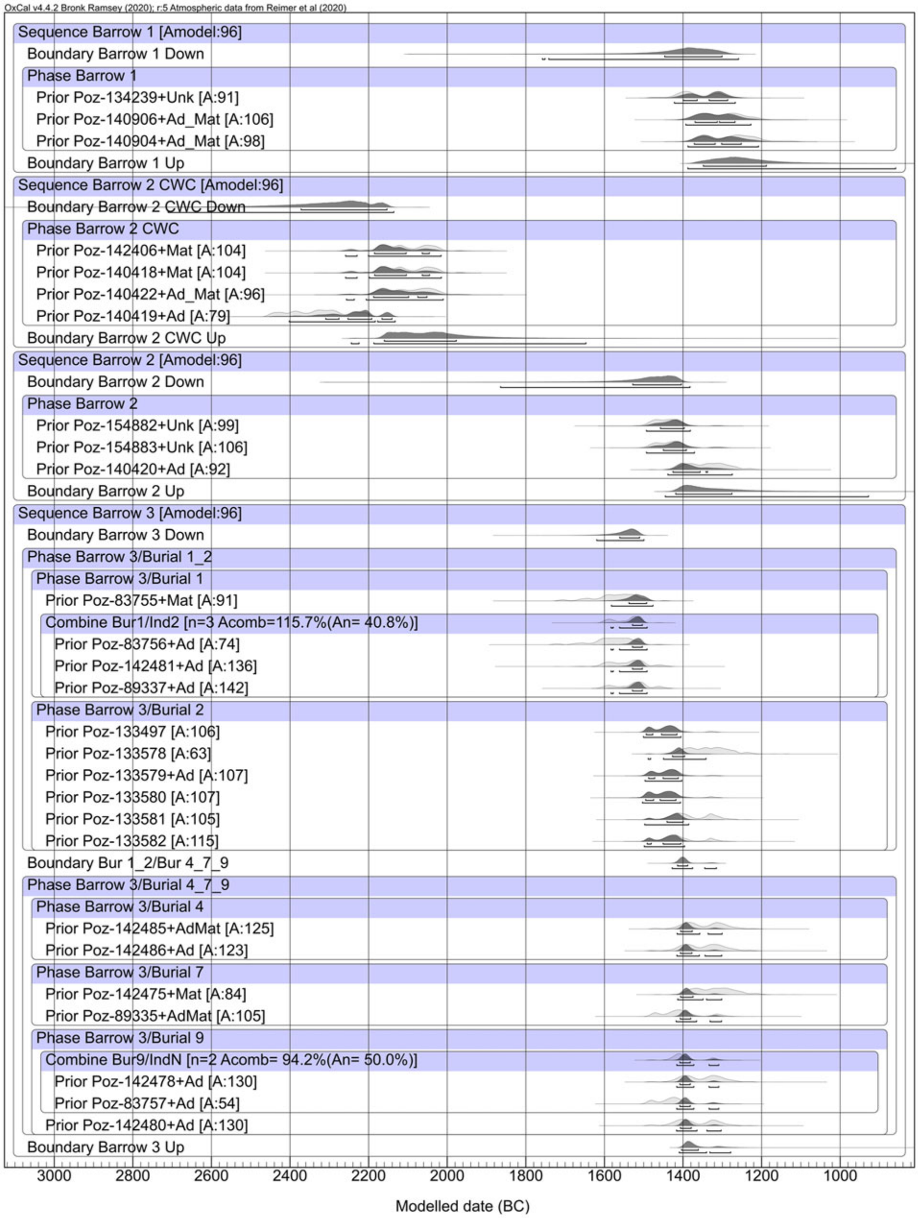

Figure 5. *Bayesian chronological model of radiocarbon dates from the Kordyshiv barrows investigated in this study. Calibrated dates of individuals who died at the age of maturus or older were corrected by the following shifts: Ad (adultus) – N(5,5), Mat (maturus) – N(20,5), AdMat (adultus/maturus) – N(15,5), Ad_Mat (adultus-maturus) – N(15,12), Unk (unknown) – U(0,30); where N(x,y) denotes Gaussian distribution with expected value "x" and dispersion "y", and U(0,30) is an uniform distribution between 0 and 30 years. The terms Prior indicate probability distributions that were calculated in a separate OxCal project (e.g. "Prior Poz-140906+Ad_Mat" being distribution of calibrated date of Poz-140906, shifted by 15±12 years) and input to the chronological model just to save calculation time.*

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

Table 2. *Time frames of using the barrows presented in this study*

Barrow/culture	From BC (68.2%) From BC (95.4%)	To BC (68.2%) To BC (95.4%)	Span yr (68.2%) Span yr (95.4%)
2/CWC	2371–2154	2161–1974	0–235
	2703–2134	2240–1635	0–451
1/KC	1443–1300	1349–1193	0–111
	1740–1259	1388–884	0–318
2/KC	1529–1405	1418–1281	0–127
	1887–1381	1445–911	0–346
3/KC whole	1565–1510	1405–1364	118–213
	1627–1424	1411–1278	56–308
3/KC earlier	*1565–1510*	*1414–1389*	*91–145*
	1627–1424	*1428–1316*	*38–214*
3/KC later	*1414–1389*	*1405–1364*	*0–24*
	1428–1316	*1411–1278*	*0–81*

Makarowicz et al. (2021), who reported $\delta^{15}N$ values ranging from 8.0 to 12.0‰ and concluded the absence of the reservoir effect in the reported ^{14}C dates. In the present study, the $\delta^{15}N$ values cluster in a narrower interval (mostly between 10.0 and 10.5‰) and do not exceed 11.5‰ (Table 1), meaning that the radiocarbon reservoir effect was similarly absent in the current study.

Bayesian modeling allowed the dates from particular barrows to be grouped into separate phases without assuming any relations between the phases (Figure 5). Archaeologically, the burials in Barrow 2, however, clearly represented two different cultures (CWC and KC), i.e., deceased from two different intervals of time. Furthermore, analysis of the inventories (grave goods) of individual burials within Barrow 3 clearly distinguished two burials (1 and 2) as being earlier than Burials 4, 7, and 9. The Bayesian modeling similarly grouped their ^{14}C dates into two separate phases.

In addition to determining the phase of CWC burials in Barrow 2 and their boundaries, estimations of the time frames of KC burials in individual barrows show (Table 2; Figure 6) that these barrows were in use in slightly different time periods. Durations of use of individual barrows by both cultures (termed as *Spans* in the Bayesian model, see Table 2) appeared rather uncertain. In most cases (2/CWC, 1/KC, 2/KC) they could be estimated only as shorter than 300 to 400 years, without excluding the possibility that the barrows may have only been used within one year. An exception is Barrow 3, which as a whole was in use over at least 50 years, and most probably, over a period of 100 to 200 years.

The obtained ^{14}C determinations and their modeling make it possible to determine the sequence in which the barrows were raised, the order of appearance of graves/burials before and after the formation of the barrow mounds, as well as the time intervals in which these events took place. The absolute chronology model and the analysis of burial goods from the studied barrows in Kordyshiv (Ilchyshyn 2016) confirm the previously observed structure of cemeteries in the Upper Dniester Basin (Swiesznikow 1967; Sulimirski 1968; Machnik et al. 2011; Makarowicz et al. 2016, 2018, 2019). This was characterized by the construction of the burial mounds by Middle Bronze Age communities (Barrows 1 and 3) next to pre-existing monuments related to the activities of earlier CWC communities. It is difficult to assess the original layout of the burial mounds due to modern damage to the cemetery, but it is possible that they formed—as in the case of other necropolises from this time and place—a linear pattern, which is indicated by the "linear" proximity of the excavated mounds (Figure 1).

In the cemetery in Kordyshiv, we can also observe a rare situation in the Upper Dniester Basin wherein KC communities (after several hundred years) reused the existing mound of Barrow 2 that was originally erected by CWC communities (cf. Sulimirski 1968; Makarowicz et al. 2016). By the end of the 3rd millennium BC, the mound of this monument was formed over individual Burials 1, 2, 7, and 8 (Figure 3). The central (primary burial) was Burial 7, a male aged 20 to 25 years-at-death who was

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

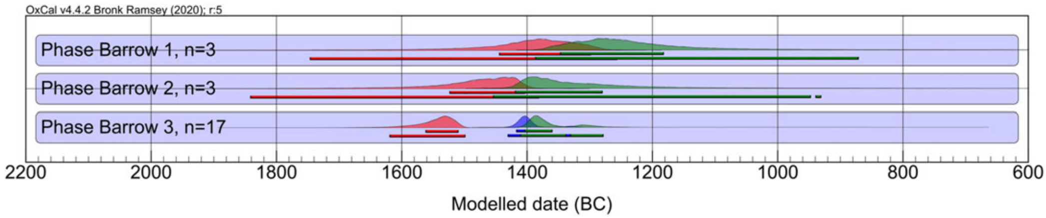

Figure 6. *Kordyshiv. Older (red), younger (green), and mid (blue) boundaries of use phases for the analyzed barrows.*

equipped with a stone axe. After his burial, a mound was erected, and several generations later another three individuals (Burials 1, 2, and 8), all males aged 40 to 50 years-at-death, were buried simultaneously (as secondary burials), as indicated by the calibration intervals of the assays obtained for Burials 1 and 2. They were buried in graves dug in the southern and northern sectors of the mound (the outlines of the grave pits were illegible). Burials of individuals representing the Middle Bronze Age KC were also recorded in Barrow 2. Their graves were dug close together in the existing barrow, several hundred years after the mound was erected by CWC communities. The obtained calibration intervals do not specify whether this occurred as part of a sequence of events (consecutive funerals) or simultaneously (joint funeral). The funeral ritual of the KC community allows for both possibilities (Makarowicz et al. 2021).

In turn, the modeling of ^{14}C dates from Barrow 3 allowed a scenario of the sequential assembly of the dead in two or three phases to be proposed (Figure 4). The oldest was represented by Burial 1 (primary) of two individuals, followed by the interim Burial 2 (collective—six people), which can also be treated as belonging to the next phase of barrow use. Secondary double Burials 4, 7, and 9 are associated with the youngest use phase. There is a hiatus of at least several decades between each of these three phases. In this case, archaeological evidence confirms that the younger burials were interred within the mound of the existing barrow. It can be assumed that the time between the use phases of this barrow was not long enough for the mourners to be ignorant of the identities of those buried in the original burials. Modeling of radiocarbon dates obtained for six collectively buried individuals, supported by the observation of a specific (antipodal, jack-like) arrangement of the deceased and the distribution of grave goods specific for the TCC (and KC) funeral ritual, suggests their simultaneous burial, with possible death at different times (Makarowicz 2010; Makarowicz et al. 2021). It is also possible that the individuals were buried in a sequence, one after the other over a short time span, which is also consistent with the KC community's rituals (Makarowicz 2008, 2019; Romaniszyn 2015).

The collective burial from Barrow 1 was by far the youngest (Figure 2). Four individuals representing the KC were cremated in situ in a grave within a wooden structure. For two of them (Individuals 3 and 4), the ranges of the modeled dates were determined to coincide (ca. 1400–1200 BC; Figure 3) and only differed slightly from that of the charcoal. However, despite its very low probability, we cannot entirely exclude that the wood used in this barrow was distinctly older than we assumed (i.e., >30 years). If so, Barrow 1 would still be younger than the age determined by our model.

Anthropological Remarks

In terms of the distribution of individuals of both sexes in the graves from Barrow 2 in Kordyshiv, only single male burials were discovered. The dominance of male burials is typical for the Corded Ware and epi-Corded Ware cultures (Bourgeois and Kroon 2017; Włodarczak 2017; Jarosz 2021; Jarosz et al. 2022). In the studied barrows of the Komarów culture, single, double, and mass inhumations or cremation burials were found. The age and sex of individuals from these contexts are variable but the prevalence of females is clearly visible. Such a distribution indicates family burials, which are

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

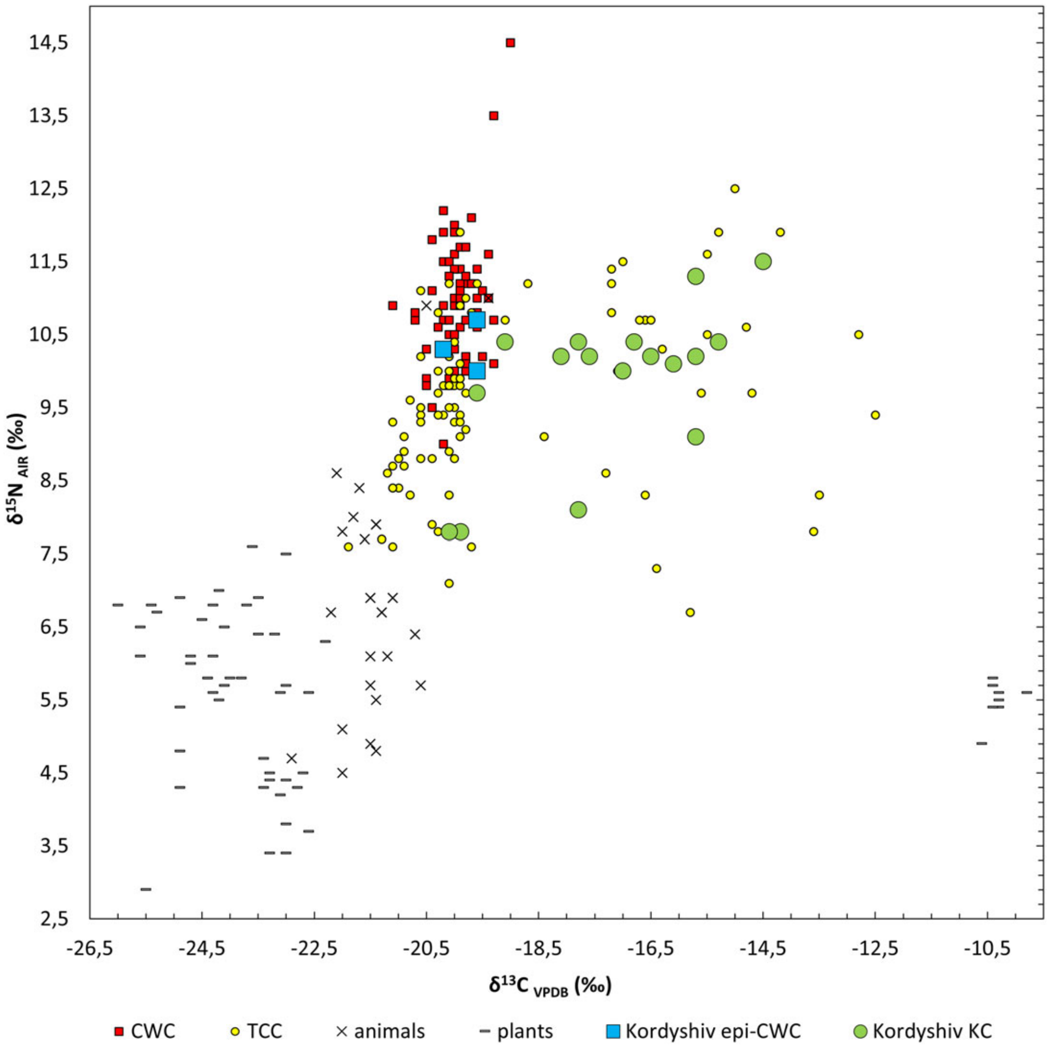

Figure 7. *Kordyshiv.* $\delta^{13}C$ *and* $\delta^{15}N$ *values in collagen samples from human bones compared to those of other cultures (after Pospieszny et al. 2021; Szczepanek and Jarosz 2022), as well as the values of archaeological animal and plant samples (after Mueller-Bieniek et al. 2019; Szczepanek and Jarosz 2022).*

distinctive for prehistoric communities due to the increased rates of female and child mortality (Hewlett 1991). Males were discovered only in double burials with females and nearly all children of different ages were found in one mass grave (Barrow 3, Burial 2) with an adult female (Table 1).

Diet

The obtained $\delta^{13}C$ and $\delta^{15}N$ values are diverse, and so to be better interpret the diet of the Kordyshiv individuals, they were compared to data from individuals representing the CWC and TCC circle from southeastern Poland and western Ukraine as well as contemporaneous animals and plants samples from these areas (Figure 7). All individuals from epi-CWC contexts exhibit similar values indicating a terrestrial diet based on C_3 plants supplemented with animal protein. Comparison with CWC samples

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

Figure 8. *Kordyshiv.* $\delta^{13}C$ *values in collagen samples from human bones against their mean calibrated absolute ages (data from Pospieszny et al. 2021; Szczepanek, Jarosz 2022).*

from other cemeteries reveals slightly lower $\delta^{15}N$ values of the burials from Kordyshiv. Results acquired from other KC individuals demonstrate a much wider range of $\delta^{13}C$ values (Figure 7). This is a consequence of a diet based on C_3 or C_4 plants as well as a mixed C_3/C_4 diet. Changes are clearly visible over time (Figure 8) with the introduction of millet, the only C_4 plant consumed in large quantities in this region at this time, in the second half of the 15th century BC (Pospieszny et al. 2021). Variability is also visible in $\delta^{15}N$ values of KC individuals. Some could be a consequence of breastfeeding (Barrow 3, Burial 2, Individual 4) or early weaning (Barrow 3, Burial 2, Individual 6), as the consumption of breastmilk causes elevated $\delta^{15}N$ values (Fuller et al. 2006). The $\delta^{15}N$ values of adult females are the most diverse with the highest value of 11.3‰ for Burial 7/Individual S from Barrow 3 and lowest value of 7.8‰ for both females buried in Burial 1 from the same barrow (Table 1).

Conclusions

Bayesian modeling of the ^{14}C dates of three burial mounds in Kordyshiv revealed the extremely important role of these monuments as long-term objects used for ritual purposes. This is consistent with

https://doi.org/10.1017/RDC.2024.40 Published online by Cambridge University Press

the current state of knowledge regarding the chronology of the structure of barrow cemeteries from the Late Eneolithic and Middle Bronze Ages in the Upper Dniester Basin. At the end of the 3rd millennium BC, the CWC community erected a mound over the primary (central) burial in Barrow 2 (no. 7), then interred the graves of three additional deceased (secondary burials) to the south and northwest of the central burial within this mound. Barrow 2 was reused again after several hundred (500–700) years, whereby KC individuals from the Middle Bronze Age were interred within it in the second half of the 2nd millennium BC. The oldest Middle Bronze Age monument, built to the southeast of pre-existing Barrow 2 built by the Late Eneolithic CWC community, was Barrow 3, in which the deceased were buried in a two-stage sequence before and after the mid-2nd millennium BC.

The youngest dated grave in Kordyshiv was Burial 1 in Barrow 1, comprising a collective burial that most probably was interred between 1400 and 1200 BC, or even afterwards. Significantly, this is the latest burial of the KC known to date, and its ^{14}C dates suggest the possibility of revising ("delaying") the chronology of the final stage of development of this cultural group (cf. Makarowicz et al. 2019, 2021).

The additional analyses of carbon and nitrogen isotopes confirm the tendencies and regularities known from the literature, showing significant differences in the diet of epi-CWC individuals buried in Barrow 2 from the individuals representing the KC. The former is typical of the CWC community and consisted of food obtained from plants that use the C_3 photosynthetic pathway and meat from terrestrial animals. In the case of the KC burials, we have confirmed previous findings that representatives of this community transitioned—likely over several generations—from a diet based on C_3 vegetation, through a mixed C_3/C_4 diet, to the consumption of foods obtained from C_4 plants—millet (Pospieszny et al. 2021).

A final important question involves the relationship between individuals interred in collective graves, particularly the children buried with the female in the collective grave as well as individuals interred as pairs and sequentially. In light of the current knowledge about mass burials in the TCC region, we know that related individuals have been found buried in one grave and between adjacent graves (Chyleński et al. 2023). Future aDNA research will provide an answer to the question about the possible kinship of individuals buried in the Kordyshiv barrows, and especially those who were buried in collective graves.

Acknowledgments. This research was supported by the Polish National Science Centre grant No. 2023/49/B/HS3/00825 lead by P.M. We would like to thank Asta Rand, PhD, for linguistic corrections and her valuable comments on the original manuscript.

Competing Interests. The authors have no competing interests to declare

REFERENCES

Anthony DW. 2007. The horse, the wheel, and language. *How Bronze–Age riders from the Eurasian Steppes shaped the modern world*. Princeton: Princeton University Press.

Aranda Jiménez G, Lozano Medina A. 2014. The chronology of megalithic funerary practices: a Bayesian approach to Grave 11 at El Barranquete necropolis (Almería, Spain). *Journal of Archaeological Science* **50**:369–382.

Aranda Jiménez G, Lozano Medina A, Sánchez Romero M, Díaz-Zorita Bonilla M. 2018. Chronology of Megalithic funerary practices in Southeastern Iberia: the Necropolis of Panoria (Granada, Spain). *Radiocarbon* **60**(1):1–19.

Bourgeois QPJ, Fontijn DR. 2015. The tempo of bronze age barrow use: modeling the EBB and flow in monumental funerary landscapes. *Radiocarbon* **57**(1):47–64.

Bourgeois Q, Kroon E. 2017. The impact of male burials on the construction of Corded Ware identity: Reconstructing networks of information in the 3rd millennium BC. *PLoS ONE* **12**(10):e0185971. doi: 10.1371/journal.pone.0185971

Brock F, Higham T, Ditchfield P, Bronk Ramsey C. 2010. Current pretreatment methods for AMS radiocarbon dating at the Oxford Radiocarbon Accelerator Unit (ORAU). *Radiocarbon* **52**(1):103–112.

Bronk Ramsey C. 1995. Radiocarbon calibration and analysis of stratigraphy: the OxCal program. *Radiocarbon* **37**(2):425–430.

Bronk Ramsey C. 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* **51**(1):337–360.

Bronk Ramsey C, Higham T, Bowles A, Hedges REM. 2004. Improvements to the pretreatment of bone at Oxford. *Radiocarbon* **46**:155–163.

Bronk Ramsey C, Lee S. 2013. Recent and planned developments of the program OxCal. *Radiocarbon* **55**:720–730.

Chyleński M, Makarowicz P, Juras A, Krzewińska M, Pospieszny Ł, Ehler E, Górski J, Taras H, Szczepanek A, Polańska M, Włodarczak P, Lasota-Kuś A, Wójcik I, Romaniszyn J, Szmyt M, Kośko A, Ignaczak M, Sadowski S, Matoga A, Grossman A, Ilchyshyn V, Yahodinska MO, Romańska A, Tunia K, Przybyła M, Szostek K, Dabert M, Götherström A, Jakobsson M and Malmström H. 2023. Patrilocality and hunter-gatherer-related ancestry of populations in East-Central Europe during the Middle Bronze Age. *Nature Communications* **14**:4395. doi: 10.1038/s41467-023-40072-9.

Cook GT, Bonsall C, Hedges REM, McSweeney K, Boronean V, Pettitt P. 2001. A freshwater diet-derived ^{14}C reservoir effect at the stone age sites in the Iron Gates gorge. *Radiocarbon* **43**(2A):453–460.

Fairgrieve SI. 2008. Forensic cremation. *Recovery and analysis*. London, New York: CRC Press.

Fuller BT, Fuller JL, Harris DA, and Hedges REM. 2006. Detection of breastfeeding and weaning in modern human infants with carbon and nitrogen stable isotope ratios. *American Journal of Physical Anthropology* **129**:279–293.

Geyh M. 2001. Bomb radiocarbon dating of animal tissues and hair. *Radiocarbon* **43**:723–730.

Goslar T, Czernik J, Goslar E. 2004. Low-energy ^{14}C AMS in Poznań Radiocarbon Laboratory, Poland. *Nuclear Instruments and Methods in Physics Research B* **223**:5–11.

Hedges RE, Reynard LM. 2007. Nitrogen isotopes and the trophic level of humans in archaeology. *Journal of Archaeological Science* **34**:1240–1251.

Heyd V, Kulcsár G, and Preda-Bălănică B. editors 2021. Yamnaya Interactions. Proceedings of the International Workshop held in Helsinki, 25–26 April 2019. Budapest: Archaeolinqua.

Ilchyshyn V. 2016. Komarivskiy gorizont bagatosharovogo kurgannogo mogilnika Kordishiv VIII na Shumshchini. Materiali i doslidzhennya z arkheologii Prikarpattya i Volini 20:259–272. In Ukrainian.

Ivanova S. 2021. Istoriya naseleniya severo-zapadnogo Prichernomorya v konce IV-III tys. do n.e. Zitomir: Buk-Druk. In Ukrainian.

Jarosz P. 2021. Barrows in the funeral space at the turn of the Final Neolithic and the beginning of the Bronze Age in the Carpathian basins of Vistula and San rivers. *Acta Archaeologica Carpathica* **56**:153–174.

Jarosz P, Mazurek M, Szczepanek A. 2022. The funeral rite of the Mierzanowice Culture in the Vistula and San river basins–graves from Rozbórz, Przeworsk district. *Sprawozdania Archeologiczne* **74**:459–484.

Lanting JN, van der Plicht J. 2001. Dating of cremated bones. *Radiocarbon* **43**:249–254.

Lee-Thorp JA. 2008. On isotopes and old bones. *Archaeometry* **50**:925–950.

Longin R. 1971. New method of collagen extraction for radiocarbon dating. *Nature* **230**:241–242.

Machnik J, Pavliv D, Petehyryč V. 2006. Barrow of the Late Corded Ware Culture from Bikiv, Drohobyč District. In: Harmata K, Machnik J, Starkel L, editors. Environment and man at the Carpathian Foreland in the Upper Dnister Catchment from Neolithic to Early Mediaeval Period. Kraków: Polska Akademia Umiejętności. p. 195–227.

Machnik J, Pawliw D, Petehyrycz W. 2011. Prehistoryczne kurhany we wsi Haji Nyżni koło Drohobycza. Kraków: Polska Akademia Umiejętności.

Makarowicz P. 2008. Elitarne pochówki z kurhanu komarowskiego w Ivanju na Wołyniu—zarys możliwości interpretacyjnych. In: Bednarczyk J, Czebreszuk J, Makarowicz P, Szmyt M, editors. Na pograniczu światów. Studia z pradziejów międzymorza bałtycko-pontyjskiego ofiarowane Profesorowi Aleksandrowi Kośko w 60. rocznicę urodzin. Poznań: Wydawnictwo Poznańskie. p. 333–352.

Makarowicz P. 2010. Trzciniecki krąg kulturowy—wspólnota pogranicza Wschodu i Zachodu Europy, Archaeologia Bimaris. Monografie, tom 3. Poznań: Wydawnictwo Poznańskie.

Makarowicz P. 2019. Dom zmarłych z kurhanu 6 w Bukivnej. Z badań nad architekturą podkurhanową w górnodniestrzańskiej enklawie kultury komarowskiej. In: Szmyt M, Chachlikowski P, Czebreszuk J, Ignaczak M, Makarowicz P, editors. Vir Bimaris. Od kujawskiego matecznika do stepów nadczarnomorskich. Studia z dziejów międzymorza bałtycko-pontyjskiego ofiarowane Profesorowi Aleksandrowi Kośko. Archaeologia Bimaris. Dyskusje, vol. 5. Poznań: Instytut Archeologii UAM. p. 737–753.

Makarowicz P, Goslar T, Górski J, Taras H, Szczepanek A, Pospieszny Ł, Jagodinska MO, Ilchyshyn V, Włodarczak P, Juras A, Chyleński M, Muzolf P, Lasota-Kuś A, Wójcki I, Matoga A, Nowak M, Przybyła MM, Marcinkowska-Swojak M, Figlerowicz M, Grygiel R, Czebreszuk J, Kochkin IT. 2021. The absolute chronology of collective burials from the 2nd millennium BC in Central-Eastern Europe. *Radiocarbon* **63**(2):669–692.

Makarowicz P, Goslar T, Niebieszczański J, Cwaliński M, Kochkin IT, Romaniszyn J, Lysenko SD, Ważny T. 2018. Middle Bronze Age societies and barrow line chronology. A case study from the Bukivna 'necropolis', Upper Dniester Basin, Ukraine. *Journal of Archaeological Science* **95**:40–51.

Makarowicz P, Kochkin I, Niebieszczański J, Romaniszyn J, Cwaliński M, Staniuk R, Lepionka H, Hildebrandt–Radke I, Panakhyd H, Boltryk Y, Rud V, Wawrusiewicz A, Tkachuk T, Skrzyniecki R, and Bahyrycz C. 2016. Catalogue of Komarów Culture barrow cemeteries in the Upper Dniester Drainage Basin (former Stanisławów province), Archaeologia Bimaris, Monographies, vol. 8. Poznań: Institute of Archaeology AMU.

Makarowicz P, Muzzolf P, Romaniszyn J. 2023. The cemetery of the Trzciniec Cultural Circle community in Łubna in light of radiocarbon chronology (AMS). *Przegląd Archeologiczny* **71**:91–115.

Makarowicz P, Niebieszczański J, Cwaliński M, Romaniszyn, Rud V, Kochkin I. 2019. Barrows in action. Late Neolithic and Middle Bronze Age Barrow Landscapes in the Upper Dniester Basin, Ukraine. *Praehistorische Zeitschrift* **94**:92–115.

Mueller-Bieniek A, Nowak M, Styring A, Lityńska-Zając M, Moskal-del Hoyo M, Sojka A, Paszko B, Tunia K, Bogaard A. 2019. Spatial and temporal patterns in Neolithic and Bronze Age agriculture in Poland based on the stable carbon and nitrogen isotopic composition of cereal grains. *Journal of Archaeological Science: Reports* **27**:101993. doi: 10.1016/j.jasrep.2019.101993.

Olsen J, Heinemeier J, Lübke H, Lüth F, Terberger T. 2010. Dietary habits and freshwater reservoir effects in bones from a Neolithic ME Germany cemetery. *Radiocarbon* **52**(2):635–644.

Pospieszny Ł, Makarowicz P, Lewis J, Górski J, Taras H, Włodarczak P, Szczepanek A, Ilchyshyn V, Jagodinska MO, Czebreszuk J, Muzolf P, Nowak M, Polańska M, Juras A, Chyleński M, Wójcik I, Lasota-Kuś A, Romaniszyn J, Tunia K, Przybyła MM, Grygiel R, Matoga A, Makowiecki D, Goslar T. 2021. Isotopic evidence of millet consumption in the Middle Bronze Age of East-Central Europe, *Journal of Archaeological Science* **126**, 105292. doi: 10.1016/j.jas.2020.105292.

Reimer P, Austin W, Bard E, Bayliss A, Blackwell P, Bronk Ramsey C, Butzin M, Cheng H, Edwards R, Friedrich M, Grootes P, Guilderson T, Hajdas I, Heaton T, Hogg A, Hughen K, Kromer B, Manning S, Muscheler R, Palmer J, Pearson C, van der Plicht J, Reimer R, Richards D, Scott E, Southon J, Turney C, Wacker L, Adolphi F, Büntgen U, Capano M, Fahrni S, Fogtmann-Schulz A, Friedrich R, Köhler P, Kudsk S, Miyake F, Olsen J, Reinig F, Sakamoto M, Sookdeo A, Talamo S. 2020. The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0–55 calk BP). *Radiocarbon* **62**(4):725–757.

Romaniszyn J. 2015. Obrzędowość pogrzebowa społeczności kultury komarowskiej w międzyrzeczu Dniestru i Prutu. *Materiały Archeologiczne* **40**:35–51.

Romaniszyn J., Makarowicz P. 2021. Real burials or cenotaphs? A study of the mysterious under-mound funerary constructions of the Trzciniec Cultural Circle, Arkheologiya i davna istoriya Ukraini 2(39):360–374.

Salazar-García DC, García-Puchol O, de Miguel-Ibáñez MP, Talamo S. 2016. Earliest evidence of Neolithic collective burials from eastern Iberia: radiocarbon dating at the archaeological site of Les Llometes (Alicante, Spain). *Radiocarbon* **58**(3):679–692.

Schiffer MB. 1986. Radiocarbon dating and the "old wood" problem: the case of the Hohokam chronology. *Journal of Archaeological Science* **13**:13–30.

Snoeck C, Brock F, Schulting RJ. 2014. Carbon exchange between bone apatite and fuels during cremation: impact on radiocarbon dates. *Radiocarbon* **56**(2):591–602.

Steuri N, Siebke I, Furtwängler A, Sönke S, Krause J, Lösh S, Hafner A. 2019. Multiple radiocarbon dating of human remains: clarifying the chronology and sequences of burials in the Late Neolithic dolmen of Oberbipp (Switzerland). *Radiocarbon* **61**(2):1697–1709.

Stuiver M, Polach HA. 1977. Discussion: reporting of ^{14}C data. *Radiocarbon* **19**:355–363.

Sulimirski T. 1968. *Corded ware and globular amphorae north-east of the Carpathians*. London: University of London, The Althone Press.

Sveshnikov IK. 1974. Istoriya nasieliennya Peredkarpattya, Podillya i Wolynii w kinci III—pochatku II tysiacholittya do nashoy eri. Kiiv: Naukova Dumka. In Ukrainian.

Swiesznikow IK. 1967. Kultura komarowska. *Archeologia Polski* **12**:39–107.

Szczepanek A, Jarosz P. 2022. Rekonstrukcja diety ludności schyłkowego eneolitu z południowo-wschodniej Polski w oparciu o analizy stabilnych izotopów węgla i azotu. In: Szczepanek A, Jarosz P, Libera J, Włodarczak P, editors. Społeczności schyłkowego eneolitu w południowo-wschodniej Polsce w świetle badań archeologicznych i analiz interdyscyplinarnych. Kraków: Wydawnictwo i Pracownia Archeologiczna Profil-Archeo. p. 263–281.

Szilágyi G, Sümegi P, Gulyás S, Molnár D. 2018. Revision of the age of construction phases of a mound dated to the Late Copper–Early Bronze Age in Eastern Hungary relying on ^{14}C-based chronologies. *Radiocarbon* **60**(5):1403–1412.

van Klinken GJ. 1999. Bone collagen quality indicators for palaeodietary and radiocarbon measurements. *Journal of Archaeological Science* **26**:687–695.

Van Strydonck M, Boudin M., De Mulder G. 2009. ^{14}C dating of cremated bone: the issue of samples contamination. *Radiocarbon* **51**(2):553–568.

Teodorovich MI. 1893. Istoriko-stastichniy opis tserkov i paraphiy Volinskoi eparkhiy. Pochaiv.

Walker PL, Miller KWP, and Richman R. 2008. Time, temperature, and oxygen availability: an experimental study of the effects of environmental conditions on the color and organic content of cremated bone. In: Schmidt, Symes SA, editors. The analysis of burned human remains. E-book. Academic Press. p. 229–236

White TD, Folkens PA. 2005. *The human bone manual*. Amsterdam: Elsevier.

Włodarczak P. 2017. Battle-axes and beakers. The final Eneolithic societies. In: Urbańczyk P, editor. Polish lands from the first evidence of human presence to the early Middle Ages, Vol. 2. 5500–2000 BC. Warszawa: Institute of Archaeology and Ethnology Polish Academy of Sciences. p. 275–336.

Zazzo A, Saliege J-F, Lebon M, Lepetz S., Moureau C. 2012. Radiocarbon dating of calcined bones: insights from combustion experiments under natural conditions. *Radiocarbon* **54**(3–4):855–866.

Cite this article: Makarowicz P, Goslar T, Szczepanek A, Yahodynska M, Ilchyshyn V, Kozak A, Romaniszyn J, Niebieszczański J, Rud V, and Pospieszny Ł. Barrow Necropolis from the 3rd and 2nd Millennia BC in Western Ukraine. A Bayesian Modeling and Isotopic Study. *Radiocarbon*. https://doi.org/10.1017/RDC.2024.40