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Absolute Chronology of the Komarów Culture in the Upper Dniester Basin in Light of Research at the Bukivna Cemetery

ABSTRACT

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The purpose of this article is to specify the absolute chronology of the Komarów culture in the Upper Dniester basin on the basis of the analysis of research results concerning barrows in Bukivna, Ivano-Frankivsk region. Statistical methods – seriation and correspondence analysis – have been used for this purpose. Thanks to the capabilities of Oxcal v. 4.2.5 calibration program, a series of radiocarbon dates for six barrows was interpreted. The sequence (succession) of construction of the excavated mounds and the time periods in which they were built were determined. Within the first group of monuments they were erected every few dozens of years. The construction period in this group can be estimated (95.4%) for a maximum of 275 years (1826–1551 BC) and with a high probability (68.2%) for 132 years (1756–1624 BC). On the basis of the findings of the Bukivna necropolis, it is to be expected that the Komarów culture community of the Upper Dniester buried their dead in the mounds for 200–300 years, *i.e.* for a shorter period of time than it was previously assumed.

Key words : Barrow, seriation, correspondence analysis, sequence of monuments, radiocarbon determinations, Komarów culture

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Introduction

Despite the existence of certain formal systematics of the Komarów culture features, its periodisation and chronology are still being discussed. Early attempts at conventional periodisation of Komarów materials (Vulpe 1961, 119ff.; Swiesznikov 1967, 73ff.; Sulimirski 1968, 93; 97ff.; Florescu 1970) can be described as predominantly intuitive.

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As the basis for distinguishing certain phases/stages of development served the analysis of “foreign” (external, non-local) characteristics in stylistic of ceramics and metal products, essentially connected with cultural centres in the Carpathian Basin and its surroundings.

In the light of older comparative analyses of the diagnostic features of these items (from before the “calibration breakthrough”), the development of the Komarów culture took place at the turn of the 2nd and 1st millennium BC, spanning over the decline of the Bronze Age and early stage of the Iron Age (Sulimirski 1968, 93, table 21; 98, table 24).

The author attributes its origins to Reinecke’s A2 period. Over the last dozen years there has been a considerable progress in the study of the chronology of this group (Dumitroaia 2000; Cavruc, Dumitroaia [eds.] 2001; Górski *et al.* 2003; Niculiča 2004–2005; Niculiča *et al.* 2004–2005; Dascălu 2007; Makarowicz 2010 tdl., Munteanu 2010, 193; Makarowicz *et al.* 2013, 110, tab. 2; Makarowicz *et al.* 2013a; Romaniszyn 2013; Lysenko *et al.* 2015; Makarowicz *et al.* 2016; Bolohan *et al.* 2015), thanks to which the period of its development was located in the first and the beginning of the second half of 2nd millennium BC.

This article serves as a contribution to the further clarification of the absolute chronology of Komarów culture in the Upper Dniester basin, based on statistical methods and interpretations of the ¹⁴C dating series from the cemetery in Bukivna, Ivano-Frankivsk region, excavated in 2010–2014 (Fig. 1) (Makarowicz *et al.* 2013, 110, tab. 2; Makarowicz *et al.* 2013a; Romaniszyn 2013; Lysenko *et al.* 2015; Makarowicz *et al.* [eds.] 2016). We have decided not to focus on presenting an extensive archaeological analysis of ceramics and metal products’ design (typochronology), which will serve as a subject of a separate publication in the monograph of the discussed necropolis (Makarowicz *et al.* [eds.] 2017). We are focused solely on the analysis and evaluation of a series of radiocarbon dates, taking into account the statistical methods of their sequencing and the possibilities that the Oxcal 4.2.5. calibration program offers. No barrows excavated in the 1930s were taken into account (Bryk 1932, Siwkówna 1937; Rogozińska 1959; Sulimirski 1968; Makarowicz *et al.* 2013; 2013a) due to the limited cognitive value of research results (incomparability, missing of a part of material) and lack of radiocarbon markings.

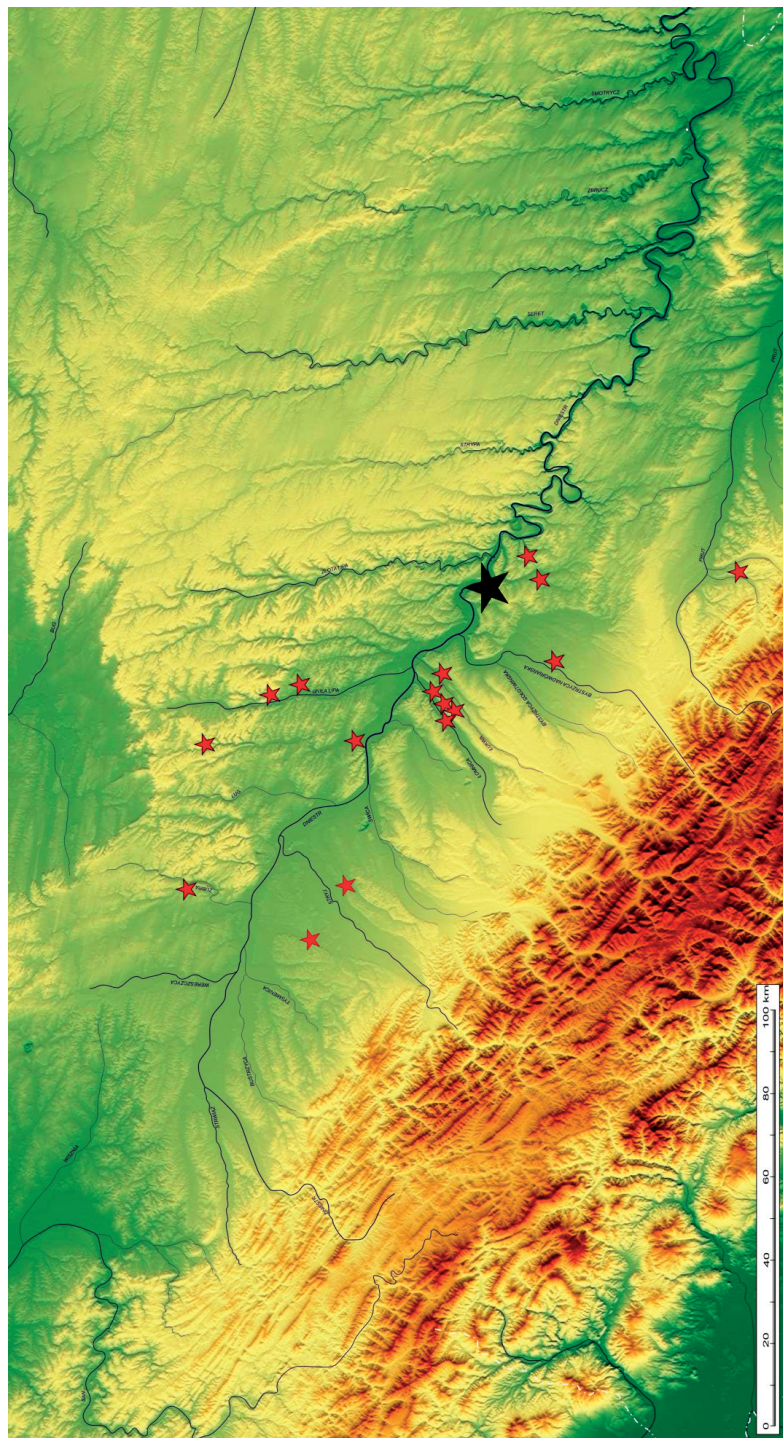


Fig. 1. Cemeteries in Bukivna compared with other barrow necropolises of the Komarów culture in the Upper Dniester basin
Ryc. 1. Cmentarzysko w Bukivnej na tle innych nekropoli kurhanowych kultury komarowskiej w dorzeczu górnego Dniestru.

State of research

I.K. Svešnikov (1958) was the first to propose the periodisation of Komarów culture, although its final version was presented several years later (Swieszchnikov 1967, 73ff.). The researcher distinguished three phases in the development of this group. The first was associated with the Middle Bronze Age on the basis of the presence of gold and bronze objects in barrow graves. For the second stage, Komarów-like vessels and single Noua culture containers and Halstatt vessels were said to be typical. The last phase was said to belong to the Early Iron Age on the basis of the presence of a fragment of an iron spike in barrow 1 in Horodyšče; the discussed grouping was to occupy the western areas of its ecumene (Swieszchnikov 1967, 73–74, tabl. X: 7–10).

The periodisation of this culture was also proposed by A. Vulpe (1961, 119ff.), based on the synchronization of Komarów and Biały Potok materials (of the Biały Potok group, recognized by J. Kostrzewski-Kostrzewski 1928) with Monteoru and Coștisa cultures. Vulpe distinguished in the area of Przedkarpacie the so-called Coștisa culture – Biały Potok, which was supposed to precede the Komarów culture in this area. It has been permanently incorporated into the Romanian literature, and the bi- or tripartite name in various configurations (most commonly Coștisa-Komarów-Biały Potok) is still in use (Dumitroaia 2000; Cavruc, Dumitroaia 2001; Górski *et al.* 2003; Niculica 2004–2005; Niculiča *et al.* 2004–2005; Dascălu 2007; Makarowicz 2010; Munteanu 2010), yet in recent years some researchers have been highlighting the possibility to distinguish a pure “Komarów” group (Niculiča 2015; Romaniszyn *et al.* 2016).

The last, but chronologically earliest of the mentioned periodisations of the Komarów culture was proposed by T. Sulimirski (1968, 93, Table 21, Plate 16–22, cf. also Dąbrowski 1972, 113–117 and table XIV–XVII; Makarowicz 2010, 29ff.). The four-phased systematic, originally presented in a monograph whose typescript was destroyed during WW2, was based mainly on the observation of reception of the stylistic features of the ceramics and metalwork produced by the communities of the Carpathian Basin and its surroundings. Phases I and II were characterized by stylistic patterns of Otomani-Füzesabony culture (features of vessel type ceramics, such as jugs with a handle reaching above the edge of the rim, decorated with spiral and knob-

like ornaments, and additionally bronze and gold items). They were to coexist with local vessels: s-profiled pots with horizontal plastic strip, vases and bowls with engravings and curves and items decorated with slanting grooves. Transcarpathian features were recognized to appear synchronously or slightly earlier than in western Lesser Poland. It should perhaps be necessary to distinguish the earliest stage in phase 1, which would be devoid of influences from the Carpathian Basin. According to the creator of the systematics, in this time horizon (phase 1 and 2?) one can also locate influences of the Coștisa culture, visible only in the style of ceramics (such as two-handle vases or vases with hatched engravings of triangles and rhombuses). In phase 3 and 4, a number of stylistic features of the Noua culture can be observed, particularly in vessel type ceramics. These are, above all, mugs with handles above the rim and two-handle vases, which coexist with vessels representing local stylistic traditions, such as S-shaped and flower pot beakers, often decorated with complex engravings, plastic motifs, S- and barrel-shaped pots and bowls of wide breadth.

Archaeometric data

During the four-year long research at the cemetery in Bukivna six barrows were excavated (1/I/ 2010, 2/I/2010, 2012; 3/I/2012, 1/II/2013; 6/2014 and 7/2014), one of which (1/II/2013) represented the “pre-Komarów” stage of development of the cemetery, associated with the late Corded Ware culture (Fig. 2; Makarowicz *et al.* 2016). The remaining mounds provided us with early/classical materials of Komarów culture (phases 1–3 according to T. Sulimirski 1968). In terms of “datable” sources, in the mounds there were located graves and numerous objects related to the funeral rite, including vessel deposits (a total of about 100 vessels, several bronze and one gold item). For the majority of vessel ceramics, mainly for vessel forms and ornamental elements analysed separately, there exist good analogies among materials from other, both flat and mound, cemeteries, as well as among sources from other enclaves of the Trzciniec culture and neighbouring groups (Carpathian Basin and its eastern environs) and the ones close chronologically – in Otomani-Füzesabony, Gyulavarsánd, Vatya, Monteoru, Costișa and Wietenberg cultures. Most of them coexist with other ornamental elements, creating elaborate motifs specific to the Komarów culture

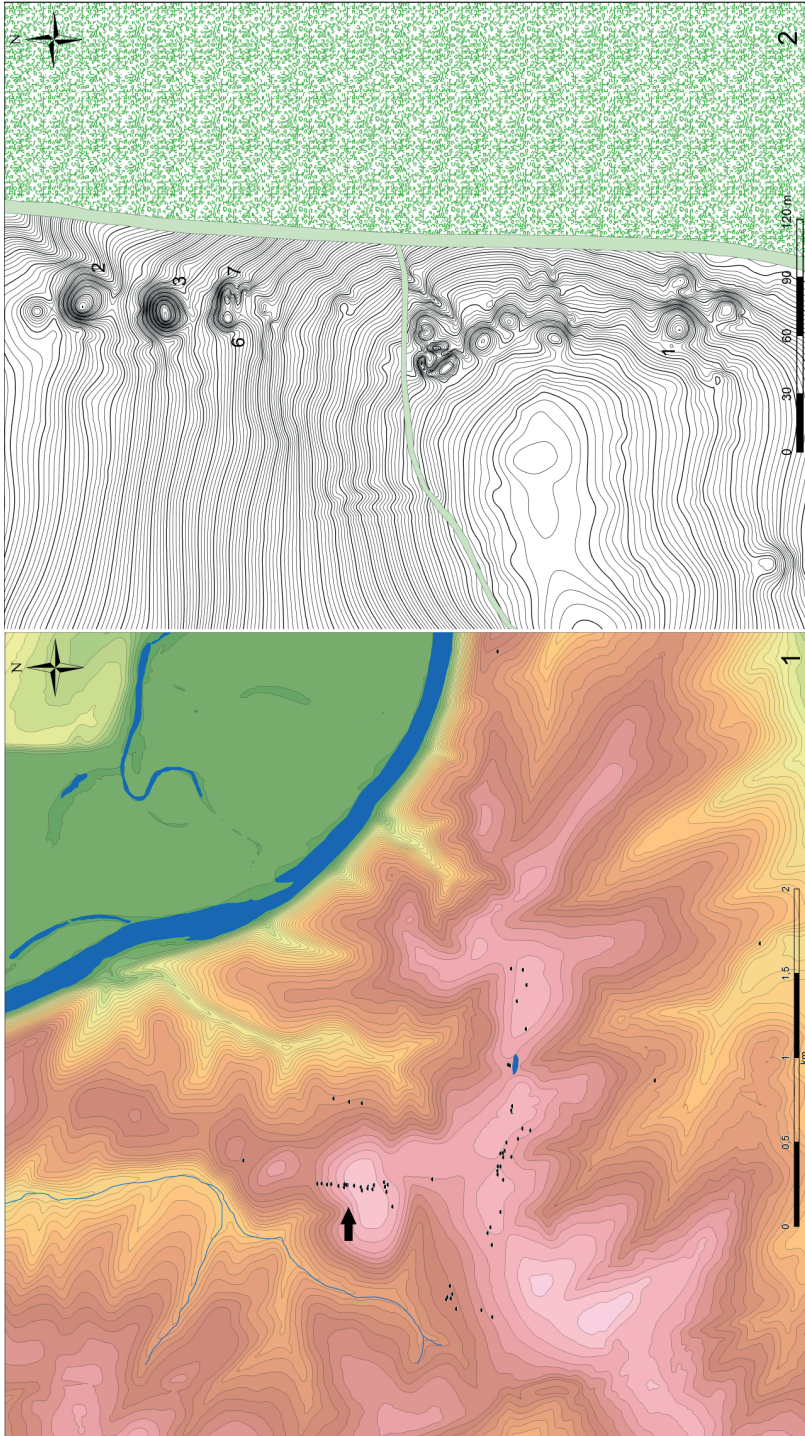


Fig. 2. Digital map of the cemetery in Bukivna (1) and topographical map of the first group of barrows (barrows after excavation and excavated and radiocarbon-dated are marked) (by Jakub Niebieszczański)
Ryc. 2. Mapa cyfrowa cmentarzyska w Bukivnej (1) oraz plan sytuacyjno-wysokościowy I grupy kurhanów (zaznaczone kopce badane wykopaliskowo i datowane radiowęglowo (wyk. Jakub Niebieszczański)

and Costișa-Komarów-Biały Potok complex (more: Makarowicz *et al.* [eds.] 2016). For metal (bronze and gold) objects analogical items can be found in the Otomani-Füzesabony, Vatya III, Wietenberg cultures and Sabatinivka-Noua complex (more: Makarowicz *et al.* 2016).

Observations made on the basis of traditional archaeological analysis (typonology, stylistic analysis) indicate that the excavated barrows from the cemetery in Bukivna were created in the first half of the 2nd millennium BC. Thanks to the aforementioned statistical methods and the interpretation of radiocarbon dates using the Oxcal v. 4.2.5 calibration program, it is possible to propose a sequence of mound construction, absolute chronometry of the whole cemetery, as well as, indirectly, the chronology of development of the Komarów culture in the Upper Dniester basin.

Statistical analysis

The statistical analysis, conducted for the excavated mounds (seasons 2010–2014) and ceramics discovered inside them, takes into account two methods – seriation and correspondence analysis. Seriation was conducted using PAST v.3 software, while correspondence analysis was carried out using the Microsoft Excel app called CAPCA v.2.2. For the purposes set forth in this study, only decorative features of ceramics, not macromorphology, were considered in both analyses (cf. Makarowicz *et al.* [eds.] 2016). Due to the extensive ornamentation of the Komarów ceramics, a separate list of elements and ornamental techniques characteristic of the Bukivna vessels, but appearing also in other necropolises of the Upper Dniester region, was proposed (Table 1).

The absolute frequency of occurrence of ceramics with distinctive ornamental features was reduced to the nominal level, where “1” denotes the presence of a given variable, while “0” – its absence. This procedure eliminated the impact of the high share of most common characteristics of the examined set, at the same time emphasizing the role of less frequently recorded specific patterns. Barrows were classified according to their chronology, using calibrated radiocarbon dating. Each of the radiocarbon-marked objects (mounds) has an assigned time slot in which it could have been used (the 2 sigma confidence level of 95.4% probability was taken into account). In the graphical presentation of the results of the correspondence analysis, axes 1 and 2 were used

Table 1. List of elements and decorative features of vessels from Bukivna (2010–2014 excavations)

Ia	– horizontal plastic cordon	VIb	– horizontal (triangular) punctures
Ib	– horizontal plastic cordon with punctures	VIc	– circular punctures
Ic	– horizontal plastic cordon with knobs	VI d	– diagonal punctures
Id	– vertical plastic cordon	VIe	– <i>furchenstich</i> diagonal punctures
Ie	– diagonal plastic cordon with imprints in the lower part	VII	– angle
If	– diagonal plastic cordon	VIIa	– angle (vertex down)
IIa	– horizontal engraved line	VIIb	– angle (vertex up)
IIb	– vertical engraved line	VIIc	– <i>furchenstich</i> angle
IIc	– diagonal engraved line (running to the top-right corner)	VIII	– arch-shaped plastic cordon
IId	– diagonal engraved line (running to the top-left corner)	IX	– rhombus with hatched engraving
IIIa	– engraved hatched triangle (vertex down)	Xa	– <i>furchenstich</i> horizontal line
IIIb	– engraved hatched triangle (vertex up)	Xb	– <i>furchenstich</i> vertical line
IIIc	– engraved triangle filled with punctures (vertex down)	Xc	– <i>furchenstich</i> semicircle heading down
IIId	– engraved triangle filled with punctures (vertex up)	Xd	– <i>furchenstich</i> triangle with vertex down
IVa	– knob with a semicircle heading down	Xe	– <i>furchenstich</i> diagonal line
IVb	– knob with a semicircle heading up	XIa	– wide vertical grooves
IVc	– circular knob	XIb	– wide horizontal grooves
IVd	– encircled knob	XIc	– wide diagonal grooves
IVe	– oval knob	XId	– wide diagonal grooves with holes
Va	– semicircle heading up	XII	– engraved wavy line
Vb	– semicircle heading down	XIII	– holes
VIa	– vertical (triangular) punctures	XIV	– plastic “mustache” reaching the handles in a semicircular way
		XV	– horizontal engraved “ladder”
		XVI	– fingerprints
		XVII	– semicircular “grooves”

every time. After cumulation they fully reflect the structure among the variables (decomposition of chi-square statistics).

After first trials, it was decided to remove variables IIIb, IVe and IXc as they were loaded with too much inertia, affecting the “unnatural” distribution of data in the coordinate diagram. The results of the analyses more clearly show different chronology of particular mounds and thus facilitate identification of ornamental characteristics typical for subsequent periods of use of the site (Fig. 3). In the case of barrow 1/I/2010, its centred position within the sequence of all the examined monuments allows for this object to be considered chronologically intermediate. The barrows 7/I/2014 and 3/I/2012 are located at the top of the sequence and mark an older phase in the use of the cemetery. Typical features of this period include variables from Va to VIIa. Then we notice transitional features, *i.e.* those that have emerged in both older and younger barrows. This group includes variables from IId to IVc. In turn, objects 6/I/2014 and 2/I/2012, due to their later chronology,

of their profiles “in the contingency table” and thus help to distinguish certain sets of ceramic ornaments of vessels deposited in the same graves. The same conclusion applies also to transitional variables located closer to the centroid of the graph, roughly along the 1st (horizontal) axis, and to the younger features located above this axis, in the upper left quadrant. The larger the distance of the variable from the centroid of the graph, the greater their specificity with regard to the barrows of a certain chronology. A similar interpretation can also be applied to the barrows themselves. For example, object 7/I/2014 contained a more specifically decorated set of vessels than the grave 3/I/2012. Nevertheless, their relatively high proximity to one another suggests that these sets were more uniform than those of the younger mounds, which are more distanced from one another. This indicates a greater variety of ways of decorating ceramic vessels in later period of use of the cemetery. The presented results provide some preliminary interpretations concerning the chronology of historical material from the cemetery in Bukivna. The chronological ordering of barrows on the basis of statistical methods was then used as a guideline in the analysis of the obtained series of radiocarbon dates.

Absolute dating

In Poznań Radiocarbon Laboratory and NSF-Arizona AMS Laboratory, University of Arizona, Tuscon, 30 radiocarbon dates were obtained with AMS technique from charcoal (27 dates, mainly oak) and burned human bones (three dates) (Table 2). Samples were valorized according to the procedure proposed by J. Czebreszuk and M. Szmyt (2001). The standard deviation encompassed 30–40 years. Three datings were conducted for the Corded Ware culture barrow 1/II/2013, the remaining 27 for the Komarów culture barrows: respectively: two for the barrow 7/I/2014, three for the barrows 1/I/2010 and 2/2012, four for the barrow 3/I/2012 and 15 for the barrow 6/I/2014. Dates were calibrated using Oxcal v. 4.2.5 (Bronk Ramsey 2013) based on the Intcal 13 atmospheric curve (Reimer *et al.* 2013).

Stratigraphic and planigraphic observations and earlier typochronological studies (Makarowicz *et al.* 2016) revealed that each of the mounds was erected in a one-off manner (in one chronological horizon), *i.e.* all the objects found there were built at the same time – before the embankment was erected.

Table 2. Bukivna, Tlumach district, Ivano-Frankivsk region, Ukraine. Registry of radiocarbon dates (Oxcal v 4.2.5 – Bronk Ramsey 2013)

No.	Barow	feature/ deposit	Conv BP	Cal BC (68,2%)	Cal BC (95,4%)	No. lab.	Material	Sample category	Commentary
1.	Barow 1/1/2010	feature 1	3260 ± 35 BP	1608–1581 (20%) 1562–1500 (48,2%)	1621–1450 (95,4%)	Poz-39760	charcoal	IIA	oak
2.	Barow 1/1/2010	feature 2	3410 ± 35 BP	1749–1661 (68,2%)	1871–1845 (4,5%) 1812–1803 (1%) 1776–1623 (89,9%)	Poz-39759	charcoal	IIA	oak or alder
3.	Barow 1/1/2010	deposit K	3290 ± 30 BP	1611–1539 (68,2%)	1633–1501 (95,4%)	Poz-39762	charcoal	IIA	from under a pin; oak
4.	Barow 2/1/2010/12	feature 3	3390 ± 30 BP	1737–1715 (19,5%) 1696–1643 (48,7%)	1751–1619 (95,4%)	Poz-53784	charcoal	IIA	oak
5.	Barow 2/1/2010/12	feature 3	3300 ± 30 BP	1616–1595 (17,8%) 1589–1532 (50,4%)	1643–1504 (95,4%)	Poz-53788	charcoal	IIA	oak
6.	Barow 2/1/2010/12	feature 4	3355 ± 30 BP	1686–1619 (68,2%)	1740–1713 (7,7%) 1697–1602 (78,6%) 1585–1544 (8,5%) 1539–1535 (0,6%)	Poz-53789	charcoal	IIA	oak
7.	Barow 3/1/2012	feature 1	3270 ± 30 BP	1608–1582 (22,4%) 1561–1506 (45,8%)	1623–1496 (92,7%) 1475–1460 (2,7%)	Poz-53790	charcoal	IIA	oak
8.	Barow 3/1/2012	feature 1	3415 ± 30 BP	1749–1683 (62,4%) 1675–1665 (5,8%)	1870–1846 (4,1%) 1775–1629 (91,3%)	Poz-53785	charcoal	IIA	0.6mgC; oak
9.	Barow 3/1/2012	feature 1, SE part	3425 ± 30 BP	1765–1685 (68,2%)	1875–1842 (7,9%) 1817–1799 (2,8%) 1780–1638 (84,7%)	Poz-53787	charcoal	IIA	oak
10.	Barow 3/1/2012	feature 2	3455 ± 30 BP	1872–1844 (18,2%) 1813–1802 (6,2%) 1777–1737 (30,7%) 1715–1696 (13,1%)	1878–1691 (95,4%)	Poz-53783	charcoal	IIA	oak

Continued Table 2

No.	Barow	feature/ deposit	Conv BP	Cal BC (68,2%)	Cal BC (95,4%)	No. lab.	Material	Sample category	Commentary
11.	Barow 6/I/2014	feature 1, „a plank”	3365 ± 35 BP	1727–1725 (1,5%) 1692–1620 (66,7%)	1746–1603 (88,4%) 1585–1544 (6,7%) 1638–1635 (0,4%)	Poz-69113	charcoal	IIA	oak
12.	Barow 6/I/2014	feature 1, element A	3395 ± 35 BP	1741–1714 (23,6%) 1700–1642 (44,6%)	1862–1852 (1%) 1772–1614 (94,4%)	Poz-72955	charcoal	IIA	oak
13.	Barow 6/I/2014	feature 1, element B	3310 ± 35 BP	1627–1595 (23,7%) 1589–1532 (44,5%)	1682–1675 (1,1%) 1666–1505 (94,3%)	Poz-69114	charcoal	IIA	oak
14.	Barow 6/I/2014	feature 1, element E	3300 ± 35 BP	1618–1531 (68,2%)	1662–1501 (95,4%)	Poz-72956	charcoal	IIA	oak
15.	Barow 6/I/2014	feature 1, element F	3285 ± 35 BP	1612–1527 (68,2%)	1644–1496 (93,8%) 1475–1460 (1,6%)	Poz-69115	charcoal	IIA	oak
16	Barow 6/I/2014	feature 1, element B	3339 ± 31 BP	1683–1609 (59,6%) 1579–1563 (8,6%)	1730–1721 (1,7%) 1692–1530 (93,7%)	AA-106308	charcoal	IIA	oak
17.	Barow 6/I/2014	feature 1, element B	3340 ± 32 BP	1684–1609 (60,2%) 1578–1564 (8%)	1731–1720 (2,1%) 1693–1530 (93,3%)	AA-106309	charcoal	IIA	oak
18.	Barow 6/I/2014	feature 1, element B	3394 ± 32 BP	1740–1712 (22,9%) 1699–1643 (45,3%)	1766–1617 (95,4%)	AA-106310	charcoal	IIA	oak
19.	Barow 6/I/2014	feature 1, element B	3368 ± 35 BP	1730–1721 (5,3%) 1692–1622 (62,9%)	1748–1606 (90,3%) 1584–1546 (5,1%)	AA-106311	charcoal	IIA	oak
20.	Barow 6/I/2014	feature 1, vessel 39	3415 ± 35 BP	1753–1662 (68,2%)	1873–1844 (6%) 1814–1801 (1,8%) 1778–1626 (87,6%)	Poz-69121	charcoal	IIA	fragment of a burnt construction in a vessel, oak
21.	Barow 6/I/2014	feature 2B, element 1	3285 ± 35 BP	1612–1527 (68,2%)	1644–1496 (93,8%) 1475–1460 (1,6%)	Poz-72957	charcoal	IIA	oak
22.	Barow 6/I/2014	feature 2B, element 2	3400 ± 40 BP	1744–1643 (68,2%)	1876–1841 (4,4%) 1820–1797 (1,9%) 1781–1611 (89,2%)	Poz-72958	charcoal	IIA	oak

No.	Barow	feature/ deposit	Conv BP	Cal BC (68,2%)	Cal BC (95,4%)	No. lab.	Material	Sample category	Commentary
23.	Barow 6/I/2014	feature 2A, skeleton 1	3355 ± 30 BP	1686–1619 (68,2%)	1740–1713 (7,7%) 1697–1602 (78,6%) 1585–1544 (8,5%) 1539–1535 (0,6%)	Poz-73406	burnt human bones	IIIA	0,1%N 0,3%C carbonate
24.	Barow 6/I/2014	feature 2A, skeleton 3	3440 ± 40 BP	1871–1845 (11,8%) 1811–1804 (2,9%) 1776–1688 (53,4%)	1881–1658 (95,4%)	Poz-73405	burnt human bones	IIIA	0,4mgC, 0,3%N 0,4%C carbonate
25.	Barow 6/I/2014	feature 3	3180 ± 35 BP	1497–1470 (25,4%) 1465–1427 (40,7%)	1526–1396 (95,4%)	Poz-69116	charcoal	IIA	0,5mgC; too late?
26.	Barow 7/I/2014	feature 6	3390 ± 35 BP	1737–1715 (19,4%) 1696–1641 (48,8%)	1862–1862 (0,7%) 1772–1612 (94,7%)	Poz-69117	charcoal	IIA	oak
27.	Barow 7/I/2014	feature 7	3425 ± 30 BP	1765–1685 (68,2%)	1875–1842 (7,9%) 1817–1799 (2,8%) 1780–1638 (84,7%)	Poz-69118	charcoal	IIA	oak
28.	Barow 1/II/2013	Bank of the mound, S-part	3840 ± 35 BP	2397–2385 (4,5%) 2347–2271 (38,4%) 2259–2207 (25,4%)	2458–2202 (95,4%)	Poz-58471	charcoal	IIIC	0,9mgC
29.	Barow 1/II/2013	Bank of the mound, N-part	3830 ± 35 BP	2339–2205 (68,2%)	2457–2417 (6,9%) 2409–2197 (85,9%) 2167–2150 (2,6%)	Poz-58549	charcoal	IIIC	
30.	Barow 1/II/2013	feature 1	2925 ± 35 BP	1192–1172 (11,4%) 1167–1143 (13,6%) 1132–1056 (43,2%)	1222–1013 (95,4%)	Poz-58472	Human bones	IIIA	carbonate; date is too late

Three dates obtained for the Corded Ware period barrow were omitted in further analysis. Other radiocarbon dates refer to the Komarów period of use of the necropolis. Most were achieved from charcoal coming from wooden – mainly oak – ritual constructions. The ageing of the obtained results (old wood effect) and the variation in age values associated with sampling from different tree rings (Goslar, Walanus 2004) are therefore to be expected. It should be noted, however, that scarce human bones in barrow 6 (objects 2A and 2B) generally coincide with the dates obtained from the coals of this barrow. The credibility of chronology of the Komarów period of cemetery use is increased by the performance of the series of ^{14}C datings for the analysed barrow (from 2 to 15 dates).

The oldest date is the charcoal dating from feature 2 in barrow 3/2012 (Poz-53783, tab. 2, item 6). With a probability of 95.4% it can be located in the 1878–1691 BC period. At the confidence level of 1σ (68.2%) the most reliable ranges are 1777–1737 BC (30.7%) and 1872–1844 BC (18.4%). The youngest date was received from barrow 6/2014, from the burnt wooden ritual construction (Poz-69116, tab. 2, item 25). After calibration, at 2σ level, its value is in the range of 1535–1396 BC (95.4%), while the most likely period in 1σ version refers to the range 1465–1427 BC (40.7%). However, this date may be fraught with some error, due to a too small sample (0.5 mg C); moreover, it does not coincide with the other dating for this barrow. Therefore, as the second oldest ^{14}C date we should consider the one obtained from the wooden structure (object 1) in barrow 1/2010 (Poz-39760, tab. 2, item 1), which after calibration provided the following interval: 2σ – 1621–1450 BC (95.4%), 1σ – 1562–1500 BC (the most reliable – 48.2%). The quoted extreme dates indicate the potential life time of the Komarów period of cemetery use for 1872–1500 BC (confidence level 68.2%) or the range 1878–1450 BC, with a probability of 95.4%, thus maximally – in both versions – for almost 400 years. This period should only be considered a framework for the functioning of the necropolis in the Bronze Age.

In order to specify the chronology of particular barrows with radiocarbon dates, and, indirectly, the first group of barrows and the entire cemetery, on the basis of the options available in the Oxcal 4.2.5 program, two models of interpretations of the obtained dates were proposed (cf. Rzepecki 2014). To build interpretation models of series of

the obtained ^{14}C dates, the data from the typo-chronological analysis (of stylistic vessel ceramics and metal products) were also used, and so were the indications resulting from the serialization of macromorphological and ornamental features of vessels and correspondence analysis (more: Makarowicz *et al.* 2016).

Model I. For the first model, the R-Combine feature of a calibration program was used, calculating weighted average of dates for each barrow. This resulted in a sequence showing the arrangement of barrows on a time scale (Fig. 5). The oldest of the barrows (1/2/2013), which according to the typo-chronological assessment represents the late Corded Ware culture, can be dated for the second half of 3rd millennium BC, while others, belonging to the Komarów culture, were erected much later, roughly in the range of 1750–1550 BC. Probability distribution with common date calibration from individual barrows suggests that 7/2014 and 3/2012 should be the oldest ones, 2/2010, 2012 – younger, and the youngest – barrows 1/2010 and 6/2014.

Model II. In this model, the results of the seriation of ceramic decorations and the results of correspondence analysis were taken into account. The results of the “combined” analysis were entered in *Sequence* feature of a calibration program. All dates tagged as *outliers*

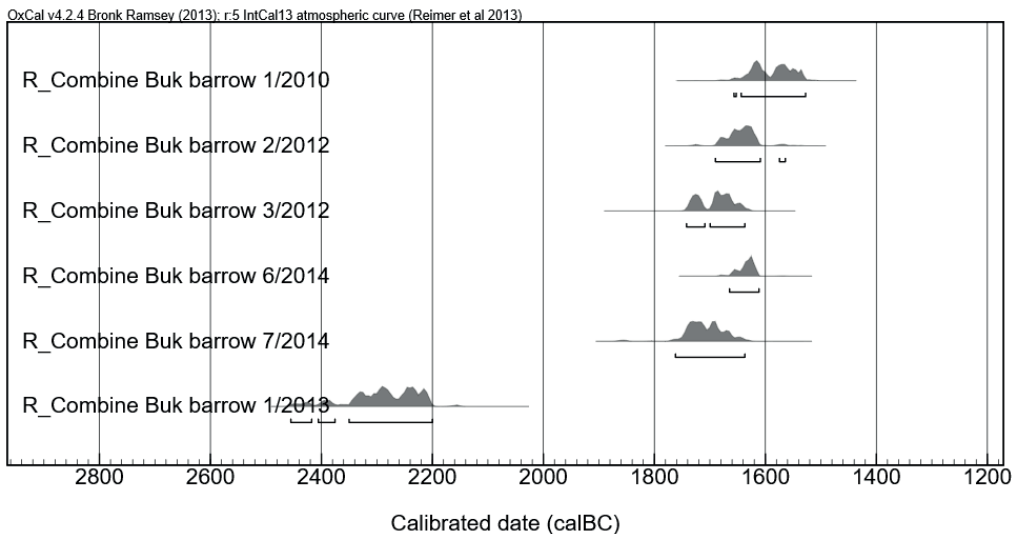


Fig. 5. Calibration of radiocarbon dates of the Bukivna barrows (Model I)

Ryc. 5. Kalibracja dat radiowęglowych z kurhanów w Bukivnej (Model I)

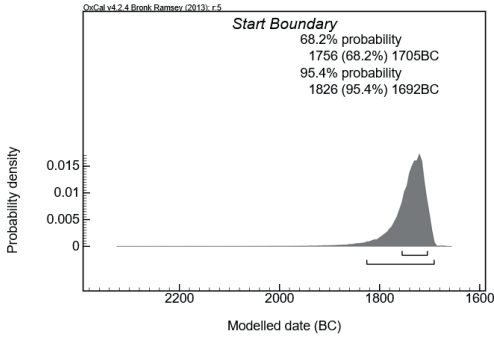


Fig. 6. Dating of the beginning of the construction of Komarów barrows in Bukivna (model II)
Ryc. 6. Datowanie początku wznoszenia kurhanów „komarowskich” w Bukivnej (model II)

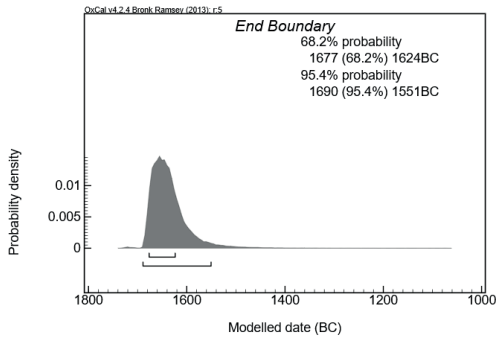


Fig. 7. Dating of the end of the construction of Komarów barrows in Bukivna (model II)
Ryc. 7. Datowanie końca wznoszenia kurhanów „komarowskich” w Bukivnej (model II)

were removed. Thanks to this operation, undoubtedly diminishing the set of radiocarbon dates, a high level of compliance coefficients (A_{Modell} always above 60%) was obtained.

In the discussed model, the period of initial construction of the excavated Komarów barrows (Group I) falls in the range of 1826–1692 BC (95.4%), and probably (68.2%) it was the 1756–1705 BC period (Fig. 6). The end of the construction of the barrows is attributed to the period 1690–1551 BC (95.4%), and most likely (68.2%) it was a range of 1677–1624 BC (Fig. 7).

After nearly 500 years of cemetery use by the communities of Corded Ware culture (barrow 1 / II / 2013), the first Komarów barrow, 7/2014, was erected in 1751–1692 BC (95.4%), probably (68, 2%) in the period of 1735–1701 BC. The barrow 3/2012 was built between 1744–1688 BC (95.4%), most likely (68.2%) in the years 1712–1695 BC. The barrow 1/2010 was erected (95.4%) during the period 1722–1658 BC, and probably (68.2%) during 1704–1679 BC. The barrow

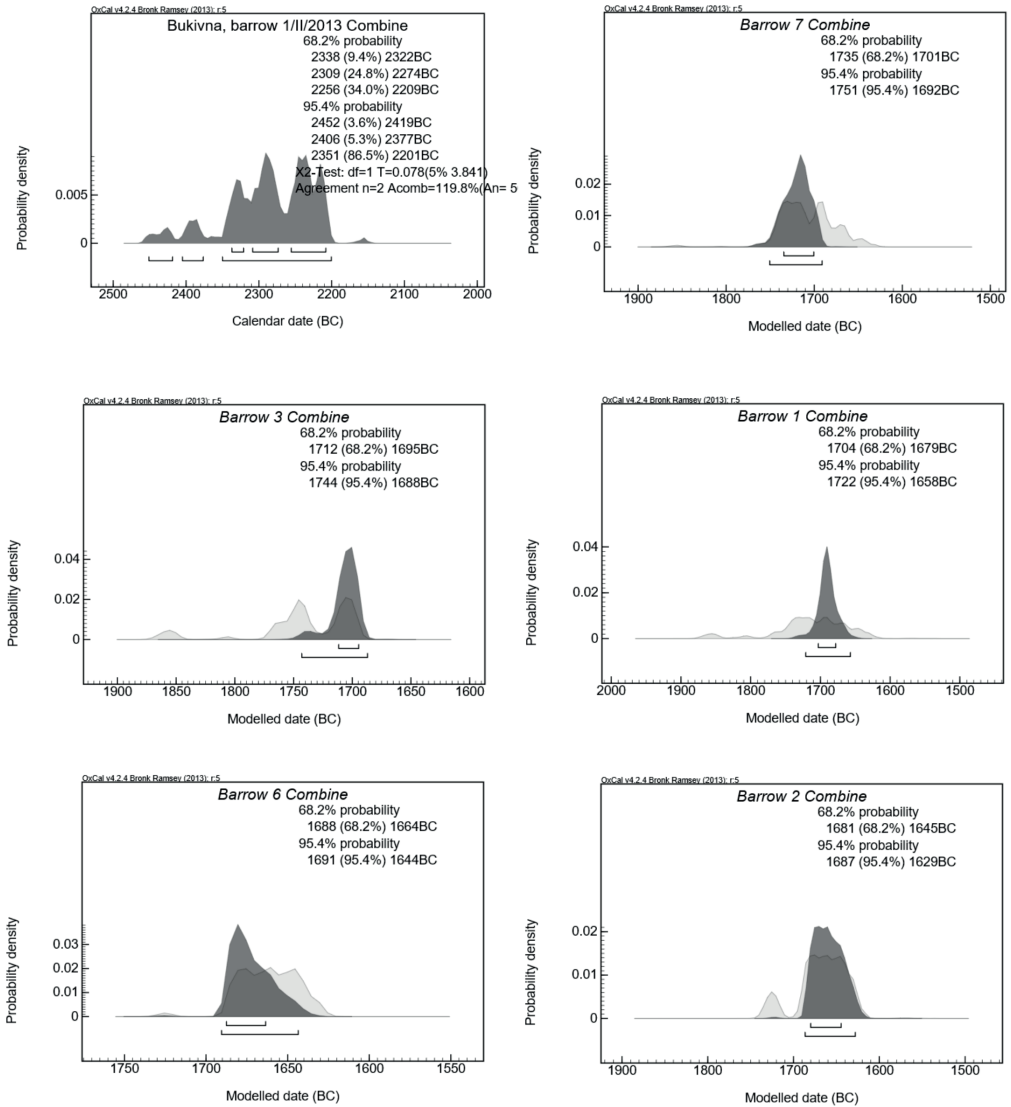


Fig. 8. Dating of individual Komarów barrows in Bukivna (model II)
Ryc. 8. Datowanie poszczególnych kurhanów „komarowskich” w Bukivnej (model II)

of 6/2014 was made in the period 1691–1644 BC (95.4%) and with a great certainty (68.2%) at the time of 1688–1644 BC. The last barrow 2/2010, 2012 was erected between 1687–1629 BC, with a great deal of credibility (68.2%) in the range of 1681–1645 BC (Fig. 8).

Conclusions: dynamics of the development of the cemetery and chronology of the Komarów culture in the Upper Dniester basin

Thanks to the typochronological analyses of the design of vessels and metalware, (more: cf. Makarowicz *et al.* 2016), but mainly thanks to seriation and correspondence analysis of decorative features of vessels, the probable sequence of erection of excavated barrows on one of the largest and most extensively studied cemeteries of Komarów culture in the Upper Dniester region was obtained.

The first barrows in the necropolis of Bukivnia were built by the Corded Ware community as early as in the second half of the third millennium BC, as proven by dating of the barrow 1/II/2013 from the second group of barrows. It was probably a group (with a linear layout) where also other Corded Ware mounds existed, but judging by the morphology and size of the monuments most of them represented the Komarów period of use of the necropolis.

More information about the use of the cemetery in Bukivna by the Komarów community can be inferred from the analysis of the first barrow group, which is also characterised by a linear layout of the barrows. Taking into account the probability of 95.4%, the time of construction of graves in this group can be estimated for a maximum of 275 years (1826–1551 BC). With a high probability (68.2%) the construction of barrows began around the middle of the 18th century BC, and ended at the end of the 17th century (1756–1624 BC). According to these calculations, the period of use for this group would last up to 132 years. The studied barrows were probably built every few dozen years. It is possible that within this linearly arranged group they were raised not one after another in one, but in two different directions. Among the examined mounds, the first monuments built were barrow 7/2014 and 3/2012, then probably the barrows 1/2010 and 6/2014, and finally the barrow 2/2010, 2012. There is another (less reliable) sequence that locates the last of the barrows after the 3/2012 and 7/2014 barrows, and 1/2010 before 6/2014. In the light of archaeological and statistical analyses and radiocarbon dates, barrow 6/2014 was added later to 7/2014, forming one oblong oval shape.

At the cemetery in Bukivna 19 barrows were investigated in total, together with the mounds recognized in the 1930s. This amount constitutes about a third of all the mounds registered in this necropolis

(Makarowicz *et al.* 2017). The analysis of the excavated grave material suggests that this sample is fully representative of the entire cemetery, *i.e.* there are two distinct stages of its use: initial – related to the funeral activity of the Corded Ware communities from the advanced stage of its development (2 half of the 3rd millennium BC) and the second – connected with the activity of Komarów groups, whose communities after 400–500 years incorporated their barrows into the existing arrangement of “Corded Ware” barrows (cf. II group of barrows), creating their own sacral-sepulchral spaces. The lack of monuments of earlier chronology suggests that perhaps the first barrow group in Bukivna consisted solely of Komarów culture mounds. It seems that individual groups of mounds, highlighted in the analysed necropolis, constituted “small cemeteries” of particular lineages, erected in a similar time horizon, for not longer than 200–250 years (8–10 generations).

The necropolis of Komarów culture in Bukivna represents the early and classical stage of development of this taxonomic unit. There are no distinct stylistic features of Noua culture which are present in other cemeteries, *e.g.* in the eponymous Komarów (Sulimirski 1968; Makarowicz *et al.* [eds.] 2016). It can therefore be assumed that the Komarów communities in the Upper Dniester basin developed during the period in which the traits of this culture in this region are visible, *i.e.* after 1550 BC (Sava 2002; Krušelnicka 2006; Makarowicz *et al.* 2016). However, on the basis of the typo-chronological analysis of materials from other necropolises of the Upper Dniester, it seems that the period of their construction was not long and limited to a few (2–3) generations (50–80 years). With the disappearance of the stylistic patterns of the Noua culture, the custom of building barrows by the Komarów culture community, one of its fundamental identity components, also disappears. It is possible that it lasts longer on the Volhynia Upland, as evidenced by the date from the barrow in Ivanju (Svešnikov 1968; Makarowicz 2008) and the stylistics of metalware and vessels in the Kordašiva barrows in Podolia, where, apart from the “classical” materials, there appear also materials of Noua culture traits (study by V. Ilčyšyn from the Regional Museum in Ternopil). This diagnosis can be confirmed by the radiocarbon dates from this site, which were handed to Poznań Radiocarbon Laboratory.

In conclusion, it can be stated that the period of development of the Komarów cultural community in the Upper Dniester basin should most

probably be located between 1800 and 1500 BC. In this relatively short time, very dynamic and demographically active communities settled in vast areas near river valleys, raising a number of mound necropolises, mainly in the former cemeteries of the population of Corded Ware culture. Further clarification of the chronology of this Upper Dniester cultural unit will be possible after obtaining radiocarbon dates from other Komarów necropolises and applying the methodology of their analysis presented in this article.

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