

The Age of Death and Fire. Dating Burial Customs by Radiocarbon and Correspondence Analysis at the Late Bronze Age Cemetery of Inzersdorf, Austria

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Abstract

The Late Bronze Age is marked by an increasing homogenization of material culture and burial customs. The cemetery of Inzersdorf, situated in the Lower Traisen Valley, Lower Austria, serves as a case study to examine diachronic changes in burial practices. This paper interprets radiocarbon data from 49 calcined human bone samples and employs correspondence analysis of grave contexts. The carefully integrated dataset enables the precise delineation of the cemetery's chronological structure in relation to the burial practices, which include body-sized graves, graves encircled by ditches and urn graves. Insights into rituals or ancestral veneration emerge from temporal discrepancies in graves with multiple occupation. The analysis indicates the cemetery's early origin in around 1400 BC, at the transition from the Middle to the Late Bronze Age, and identifies two peak phases of activity before burial practices decline in around 950 BC. The integration of typo-chronological markers, ^{14}C data, and comparisons with nearby contemporary cemeteries reveals a complex temporal framework, emphasizing the fluidity and regional variability of burial practices. This challenges assumptions of a linear development in mortuary rites and establishes an absolute and a relative chronology of the Late Bronze Age for eastern Austria.

Keywords

Late Bronze Age, radiocarbon dates, correspondence analysis, burial practices, cremation

Zusammenfassung – *Das (Zeit-)Alter von Tod und Feuer. Die Datierung von Bestattungssitten mittels Radiokarbon- und Korrespondenzanalyse anhand des spätbronzezeitlichen Gräberfelds von Inzersdorf, Österreich*

Die Spätbronzezeit zeichnet sich durch eine zunehmende Vereinheitlichung der materiellen Kultur und der Bestattungsrituale aus. Das Gräberfeld von Inzersdorf, gelegen im Unteren Traisental in Niederösterreich, dient als Fallstudie zur Untersuchung diachroner Veränderungen in den Bestattungspraktiken. Diese Studie analysiert Radiokarbonaten von 49 kalzinierten menschlichen Knochenproben

und nutzt Korrespondenzanalysen von Grabkontexten. Der sorgfältig aufbereitete Datensatz ermöglicht eine präzise Rekonstruktion der zeitlichen Struktur des Gräberfeldes in Bezug auf verschiedene Bestattungsformen, darunter körpergroße Erdgräber, Gräber mit umlaufenden Gräben und Urnengräber. Besondere Einblicke in Rituale und mögliche Formen der Ahnenverehrung ergeben sich aus den zeitlichen Unterschieden bei mehrfach belegten Gräbern. Die Ergebnisse legen nahe, dass die Belegung des Gräberfeldes um 1400 v. Chr. begann, also während des Übergangs von der Mittel- zur Spätbronzezeit. Zwei Aktivitätshöhepunkte konnten identifiziert werden, bevor die Bestattungspraktiken um 950 v. Chr. nachließen. Durch die Kombination typochronologischer Marker, der ^{14}C -Daten sowie den Vergleich mit nahegelegenen zeitgenössischen Gräberfeldern entsteht ein differenziertes zeitliches Bild. Dieses verdeutlicht die Variabilität und Flexibilität der Bestattungspraktiken in der Region und stellt die Annahme einer linearen Entwicklung von Bestattungsriten in Frage. Die Studie schafft damit sowohl eine absolute als auch eine relative Chronologie der Spätbronzezeit für Ostösterreich und trägt zu einem besseren Verständnis der kulturellen Dynamik dieser Epoche bei.

Schlüsselbegriffe

Spätbronzezeit, Radiokarbonatierung, Korrespondenzanalyse, Bestattungspraktiken, Kremation

1. Introduction

Changes in burial customs may reflect broader cultural shifts in the social structure and communal identity. The transition from tumulus graves to urn burials in flat graves unfolded in different ways across central European regions, and has been shown to occur gradually rather than abruptly.¹ However,

¹ CAVAZUTTI et al. 2022. – SØRENSEN, REBAY-SALISBURY 2023, 86–112.

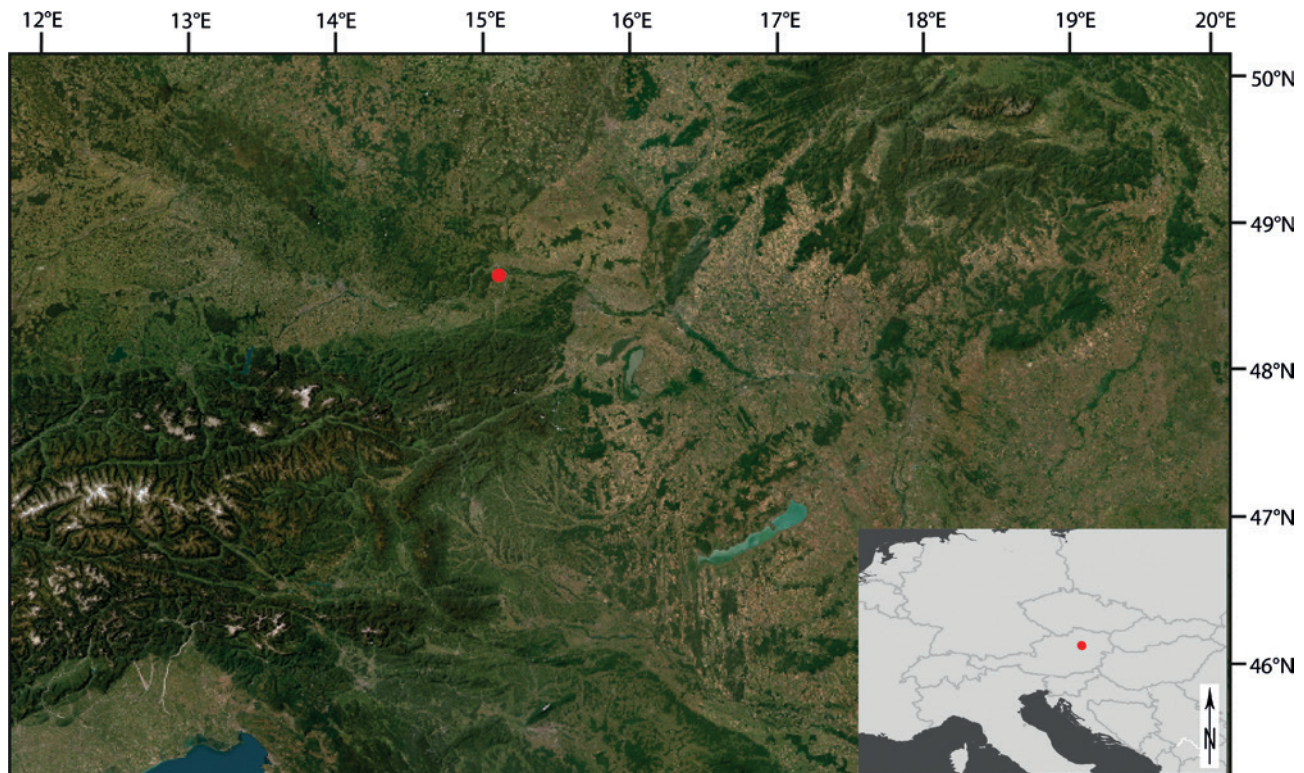


Fig. 1. Map of southeastern Central Europe. The red dot indicates the Lower Traisen Valley, which includes the sites of Inzersdorf, Getzersdorf and Franzhausen-Kokoron.

while the broad patterns of the emergence of the Urnfield phenomenon are somewhat understood, the chronological and regional variabilities within the phenomenon and their peculiarities are less well researched.² The interrelations and contextual links between individual well-researched sites often remain unclear, and a micro-scale analysis is necessary to understand how change unfolds on an individual and social level. This study illuminates the temporal timeframe of the shift in burial customs by providing a chronological framework established by criteria other than the burial practices.

Ethnological research has shown that burial rites can be elaborate, include multiple steps and span long temporal ranges.³ This is especially true for cremation burials, as the cremation process adds multiple additional steps to the funerary rites.⁴ In addition, cremated remains do not pose the same challenges as decaying corpses, allowing the burial community to handle the remains for a longer time before burial without the health risks posed by toxic decomposition products and pathogens. The chronology of cremation

graves may thus be complicated and necessitates a fine-grained analysis of the steps involved in the treatment of bodies after death.

Relative and absolute dating play vital roles in the analysis of changing burial customs. Traditional archaeological methods such as horizontal stratigraphy, seriation and correspondence analysis (CA) elucidate relative chronological aspects of archaeological finds and features, while interdisciplinary methods like radiocarbon dating provide a framework of absolute dates.

In chronological terms, the transition from the Middle to the Late Bronze Age is placed in the BA D period, from 1300 BC to 1200 BC,⁵ with the shift to the Urnfield period occurring during the later phase of BA D2. The core period of the Early Urnfield Culture (Ha A1) is assumed from around 1250/1200 BC to 1100 BC, while the Middle Urnfield period (Ha A2) corresponds to 1100 BC to 1050 BC. The Late Urnfield period encompasses Ha B1, from approximately 1050 BC to 950 BC, and Ha B2, from 950 BC to 880 BC, with Ha B3 lasting until the beginning

² WIESNER 2009, 540–570. – CAVAZUTTI et al. 2022.

³ VAN GENNEP 1909. – ROTHEN, FISCHER 2018.

⁴ OESTIGAARD 2000, 55–56. – GRAMSCH 2010, 143–210.

⁵ MÜLLER-KARPE 1974, 182–225.

of the Iron Age in around 750 BC.⁶ So far, because of the scarcity of radiocarbon dates from Lower Austria, absolute dating relied on data from neighbouring regions, suggesting a beginning of the Urnfield period in around 1300 BC or 1400 BC at the very earliest.⁷

Applying a dual approach to dating not only allows a comparison between data points, but complementary data also facilitate a finer chronological resolution and error correction.

In this study we apply a broad-scale, targeted sampling approach to radiocarbon dating cremated human remains from the cemetery of Inzersdorf ob der Traisen (Fig. 1), to overcome the limitations and constraints of both relative and absolute dating methods such as whether a grave – especially cremation burials – can be considered a closed context or the duration and definition of specific types in relative dating and wide error margins or the ‘old wood effect’ in absolute dating.⁸ The emphasis in this study is on the temporal position of the cemetery within the context of regional urnfields, ensuring comparability of the chronological sequence between cemeteries. Second, an investigation of the absolute and relative chronological placement of individual find types and variables is conducted. Third, the study examines the extent to which changes in burial customs are limited to a chronological period and whether they are consistent across the region. Combining radiocarbon dating with correspondence analysis allows the temporal sequence of changing burial customs during the advent of the early Urnfield period to be explored, as well as facilitating understanding of the chronological relationships between co-buried individuals.

1.2. The Cemetery of Inzersdorf ob der Traisen

Inzersdorf ob der Traisen is situated in the Lower Traisen Valley in Lower Austria, near the confluence of the Traisen and the Danube rivers. Its significance emerged during rescue excavations prompted by the construction of a new road, which yielded a wealth of archaeological finds and features spanning various prehistoric and historical periods.⁹ Consequently, this region stands as one of Austria’s most thoroughly researched archaeological areas, with seemingly uninterrupted settlement activity dating back to the Early

Bronze Age. Outstanding among these discoveries are the extensive early Bronze Age cemeteries Franzhausen I and II, as well as the Late Bronze Age cemeteries Franzhausen-Kokoron and Inzersdorf.¹⁰

Inzersdorf encompasses 273 graves and was in use from the onset of the Early Urnfield period (Fig. 2).¹¹ Previous studies have positioned the cemetery primarily within the Early Urnfield period, specifically in the Ha A1 and Ha A2 phases, which follow the latest Bronze Age cemetery at Getzersdorf, situated only a few hundred metres apart, dating from BA D to Ha A.¹² The substantial size, structured layout and seemingly definable occupancy duration of the cemetery make Inzersdorf an ideal case study for investigating diachronic developments in burial customs.

Although the majority of the burials at Inzersdorf are urn burials, the cemetery includes eight long, rectangular graves. Both their construction and their typological characteristics are reminiscent of the Middle Bronze Age, from 1600 BC to 1300 BC, which has led to the common assumption that they represent the transitional period from the Middle to the Late Bronze Age.¹³ Eleven circular ditches and one rectangular ditch were found, each enclosing one or two grave pits.¹⁴ The ditches have often been interpreted as demarcating burial mounds, which would indicate a similarity to the Middle Bronze Age and therefore also a possible temporal connection.

During the Middle Urnfield period there was a resurgence of burials containing artefacts with no signs of burning. Such graves constitute a substantial portion of Later Urnfield-period graves.¹⁵ Graves with an increasing number of unburned grave goods are therefore compared to urn graves that primarily contain grave goods that accompanied the body on the pyre (pyre goods) to investigate the emergence of this funerary rite. The grave goods are carefully arranged in the grave pit, often around the urn containing the burnt remains.¹⁶

Cremation graves with multiple deposits of cremated human remains pose particular challenges for chronological investigations, as they range from contemporaneous

⁶ LOCHNER 2021, 22–24.

⁷ PARE 1998, 229, 384–400. – PRIMAS 2008, 7–9. – WENINGER, JUNG 2009. – TERŽAN, ČREŠNAR 2014. – ILON 2015. – LOCHNER 2021, 22–24.

⁸ BÁNFFY et al. 2018.

⁹ GATTRINGER, NEUGEBAUER 1982. – NEUGEBAUER, GATTRINGER 1989.

¹⁰ BLES1 2012.

¹¹ LOCHNER 2013.

¹² KAUS 1971. – LOCHNER 2013.

¹³ LOCHNER 2013.

¹⁴ FRITZL 2017, 86–87.

¹⁵ LOCHNER 2013.

¹⁶ Recognizing that some objects may have served multiple or different functions, for the purposes of this analysis, all artefacts with evidence of burning are classified as pyre goods, while those with no fire modification and deliberate placement are classified as grave goods.

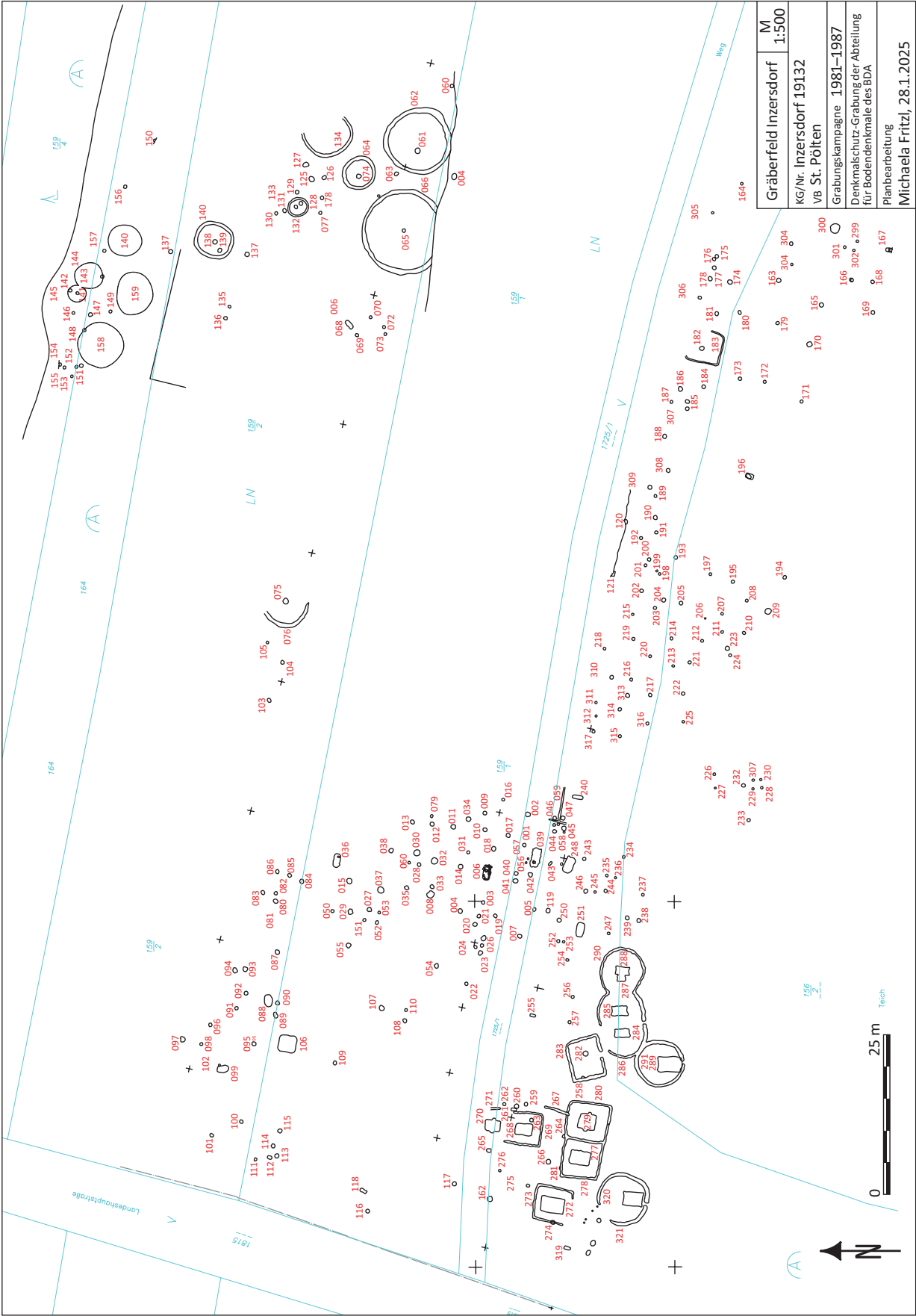


Fig. 2. Map of the cemetery of Inzersdorf.

depositions (multiple burials) to sequential depositions (consecutive burials).¹⁷ Cremations involve a complex ritual process with multiple steps, potentially covering a long time span, that need to be separated before further analysis.¹⁸ Consequently, the timing of these steps needs to be distinguished both for an individual's burial process and for co-buried individuals: the simultaneity of death, cremation, or burial of co-buried individuals as well as the time spans in between need to be addressed.¹⁹ The former may have died of the same causes, e.g. in a pandemic, but this is not necessarily the case. It has been argued that the simultaneity of cremation can be evidenced by mixed cremated human remains.²⁰ However, it has also been shown that individuals can be separated even if they were cremated on the same pyre.²¹ Osteologically, the degree of mixing in cremations can only be estimated with great uncertainty,²² and there is also the possibility of later and taphonomic mixing. Furthermore, the appearance of original contexts can be altered by a later burial process and the chronological sequences of the actual burial(s) cannot necessarily be clarified using stratigraphic methods. The typological classification of burials based on accompanying archaeological finds is hindered by their homogeneity and the broad time frame of their use, as well as the difficulty of assigning specific pyre or grave goods to individual burials due to the high degree of mixing of human remains, combined with the spatial constraints of the graves with multiple depositions.²³

1.3. Materials and Sampling Strategy

In this study 49 samples of cremated human bone were selected for radiocarbon analysis, with incomplete calcination as an exclusion criterion. Samples for radiocarbon dating were chosen from samples selected for strontium isotope analysis.²⁴ The sampling strategy first aimed at a relatively uniform spatial distribution across the cemetery. Second, we sought a balanced representation across the different time periods indicated by the typological spectrum of finds. Graves ranging from sparsely to well furnished were included to cover all sociological strata. A substantial portion of graves with multiple occupation was sampled twice or

even three times to estimate the time span between different depositions. Some individuals were further selected because of their association with objects that were atypical for this region, on the one hand, and therefore of interest in analysing cultural influences, and with objects that were particularly typical for this area, on the other hand, as they are considered chronologically significant. This approach ensures that the whole spectrum of burial rites and material culture can be accurately placed in an absolute chronological order.

This strategy resulted in 28 samples from single burials and 21 samples from graves with multiple occupations. In six cases samples were taken from two individuals per grave, and in one case from three individuals per grave. Six single samples were taken from graves with at least two depositions of human remains; in these cases the sample was taken from the better-represented individual. A clear association of the sample with the individual represented in the burial was paramount for the selection.

1.4. Methods

Radiocarbon dates of cremated human remains were measured at the Royal Institute for Cultural Heritage (RICHEL) in Brussels, Belgium, using the protocol outlined in Marine Wojcieszak et al.²⁵ During cremation, carbon in human bone undergoes an exchange process with carbon from the wood used for firing the pyre.²⁶ Radiocarbon dates from cremated human remains thus provide a mixed signal, a date that is related to both the life of the cremated person and that of the firing wood, and a possible 'old wood effect'²⁷ needs to be considered. The degree to which carbon exchange affects human cremated remains is still under discussion.²⁸

Conventional dates were calibrated using OxCal 4.4.4²⁹ based on the atmospheric data from Paula Reimer et al.³⁰ To estimate the limits of the cemetery's occupancy duration, the functions *boundary*, *span*, *difference*, *first* and *last* were applied. Some dates fall into the Hallstatt plateau, a flat segment of the calibration curve.³¹ We employed Bayesian modelling to integrate radiocarbon dates with other lines of evidence such as the archaeological context and artefact

17 LÜDEMANN 1994, 431. – WAHL 1994. – WIESNER 2009, 485–488. – GRAMSCH 2010, 213–218. – HESS 2013, 25–26. – FRITZL 2017, 7–10.

18 OESTIGAARD 2000, 55–56. – GRAMSCH 2010, 143–210.

19 FRITZL 2017, 88–90.

20 LOCHNER 2013.

21 FRITZL et al. in prep.

22 WAHL 1982. – GROSSKOPF 2004, 126–129.

23 FRITZL 2017, 68–71, 128–130, 209.

24 FRITZL et al. 2024.

25 WOJCIESZAK et al. 2020.

26 OLSEN et al. 2013. – SNOECK, BROCK, SCHULTING 2014. – CAPUZZO et al. 2023.

27 VAN STRYDONCK, BOUDIN, DE MULDER 2010. – OLSEN et al. 2013. – SNOECK, BROCK, SCHULTING 2014. – VAN STRYDONCK 2016. – CAPUZZO et al. 2023.

28 ROSE, MEADOWS, HENRIKSEN 2020. – CAPUZZO et al. 2023.

29 BRONK RAMSEY 2009.

30 REIMER et al. 2020.

31 MANNING et al. 2018. – FAHRNI et al. 2020. – ROSE et al. 2022.

typologies.³² To see if multiple dates from graves with multiple occupations can be described as consistent, they were analysed with *R_combine* in *OxCal* and thus subjected to a chi-square test.³³

Statistical techniques for chronological modelling of radiocarbon dates include kernel density estimation (KDE), which estimates the probability density function of a random variable from finite data. KDE allows peaks, increases and decreases in archaeological activity at a site to be identified. By using a weighted smoothing kernel function, KDE provides a smooth data distribution representation, visually displayed in density plots which help mitigate the distortions introduced by the calibration process on the shape of the curve. These plots help to detect patterns, peaks and anomalies not evident in histograms.³⁴ Radiocarbon calibration can significantly distort the shape of KDE curves, as the non-linear nature of the calibration curve can introduce artificial peaks, plateaus or multimodal distributions. These effects can lead to misleading interpretations of temporal patterns, such as suggesting false activity clusters or gaps in the archaeological record. However, since the calibration curve does not show any plateaus or calendar age steps during this period, this is unlikely to have a significant effect on the results.

Seriation and correspondence analysis based on the concepts of ‘closed find’ and ‘type’³⁵ were used to establish relative chronologies from objects found in graves. A ‘closed find’ comprises two or more artefacts deposited at the same time, with no new items added after deposition.³⁶ This, however, does not necessarily imply their contemporaneous manufacture or use. Whilst burials are frequently cited as examples of closed finds,³⁷ ethnographic studies have demonstrated that burial rituals are often complex and unfold over extended periods of time.³⁸ This complexity is particularly evident in cremation burials, which do not pose the same challenges to the community as a decaying corpse and may include significant intervals between death, cremation and burial, during which bone curation was practiced.³⁹ There is little evidence for the reopening of graves

at Inzersdorf, although many contexts were disturbed by agricultural activities. In this study we assume that objects deposited together in one grave have a chronological relationship to each other and to the cremated bones buried in the same context.

Comprehensive typological studies on the Urnfield period in the Lower Austrian-Moravian region have been presented by Jiří Říhovský⁴⁰ and Michaela Lochner and Irmtraud Hellerschmid.⁴¹ For comparability, we closely adhered to the typological classification system established at the nearby Late Bronze Age cemetery of Franzhausen-Kokoron in this study.⁴² The three hierarchical levels of the typology comprise the basic form, type and variant, and are primarily based on technical features. Basic forms of ceramics include bicones, bottles, cylindrical-necked vessels, funnel-necked vessels, conical-necked vessels, bowls, cups and pots.⁴³ More details on the typology, types and variants, as well as the classification of bronze and other finds, can be found in the supplementary materials (Appendix 1, Start Matrix CA⁴⁴).

Combinatorial statistics, or chronological seriation, arranges finds into a chronological sequence based on their types. Mathematical algorithms optimize the arrangement of incidence points along a diagonal, revealing average chronological patterns. Correspondence analysis (CA), similar to reciprocal averaging, replaces the rows and columns of an incidence matrix with eigenvectors to position similar find complexes closer together. Unlike the incidence matrix, CA typically begins with a contingency table that considers the frequencies of occurrences.⁴⁵

Seriation and CA do not provide a time scale or intervals between finds; this information needs to be derived from other sources such as absolute dating methods like radiocarbon dating, stratigraphy, written sources or comparison with other sites. Further, type combinations may be influenced by other factors such as gender, social affiliation or geographical peculiarities. A key issue with correspondence analysis (CA) is its sensitivity to data structure and sample size. Small or sparse datasets can yield unstable results, complicating interpretation. Moreover, CA assumes linear

32 BUCK, CAVANAGH, LITTON 1996, 201–292. – MEADOWS et al. 2020. – ROSE et al. 2022.

33 SHENNAN 1988, 65.

34 BRONK RAMSEY 2009. – BRONK RAMSEY 2017.

35 MONTELIUS 1903, 1–21. – EGGERT 2012, 143.

36 TRACHSEL 2004, 145–146.

37 BØLVIKEN et al. 1982. – RINGROSE 1992. – EGGERT 2012, 52.

38 VAN GENNEP 1909, 146–165. – TURNER 1969, 106–107. – ORSCHIEDT 1997. – OESTIGAARD 2000, 55–56. – ROTHEN, FISCHER 2018.

39 WEISS-KREJCI 2001. – WEISS-KREJCI 2013. – SØRENSEN, REBAY-SALISBURY 2023, 113–135.

40 ŘÍHOVSKÝ 1963. – ŘÍHOVSKÝ 1972. – ŘÍHOVSKÝ 1979. – ŘÍHOVSKÝ 1982.

41 LOCHNER 1991b. – LOCHNER, HELLESCHEMID 2008.

42 LOCHNER, HELLESCHEMID 2016.

43 LOCHNER, HELLESCHEMID 2008.

44 The starting and final matrix of the correspondence analysis and eigenvalues of the graves and types are available as Online Appendix 1: doi: 10.1553/archaeologia109s177-A1.

45 STADLER 2005, 18, 27.

relationships, which may not reflect complex archaeological patterns.⁴⁶

A typo-chronological assessment of the finds combined with correspondence analysis established the chronological sequence of graves within the cemetery⁴⁷ using Past 4.17⁴⁸ and CA-PCA analysis for Excel.⁴⁹ A preliminary elimination was performed to reduce the data suitable for seriation and CA (more than one type per grave and one type in multiple graves). Subsequently, duplicates (temporally irrelevant types) were eliminated, and the data were reduced to relevant columns and rows. This process was repeated twice (See Appendix 1, Final Matrix CA for remaining types). The gradient of the curve was not further optimized in order to retain as many graves as possible in the matrix, especially those with few grave goods.

Geostatistical modelling leverages the principles of spatial correlation, allowing for the estimation of values at unsampled locations based on known data points. Techniques such as kriging, a geostatistical interpolation method, utilize variograms to quantify the spatial structure of the data, facilitating accurate predictions and risk assessments.⁵⁰ Empirical Bayesian kriging (EBK) integrates kriging with Bayesian inference to enhance estimates of spatially correlated variables. It addresses parameter uncertainty by combining prior information with observed data. The spatial correlation structure is derived directly from the data, enabling automatic adjustment of weights based on each observation's relevance to prediction locations. Using a hierarchical modelling framework, EBK delivers point estimates and uncertainty measures like credible intervals, refining predictions with greater accuracy. Cokriging interpolates spatial data by utilizing a primary variable of interest and one or more spatially correlated secondary variables to enhance prediction accuracy. It models cross-covariances between datasets, improving estimates where primary data is sparse by leveraging additional, often more accessible, secondary data.⁵¹

Geostatistics of the CA data and the radiocarbon data was performed using ArcGIS. Medians of calibrated radiocarbon dates were used as single estimates. While this is a simplification and not ideal – particularly in calibration plateaus – it can be acceptable in more stable sections of the curve. This approach is used with full awareness of its

potential biases. Power semi-variograms were produced to evaluate the spatial autocorrelation and a cross-validation graph was produced to compare the predicted with the measured data.⁵² Interpolation through kriging was carried out using Past 4.17.⁵³

The combination of CA and radiocarbon dating offers a powerful approach for exploring the temporal and spatial dynamics of archaeological assemblages. CA provides a statistical framework for identifying patterns of association between categorical variables, while radiocarbon dating provides calibrated probability density functions for individual archaeological contexts or samples. Several challenges resulting from inherent differences in data types, scales and interpretive frameworks⁵⁴ have to be addressed. Radiocarbon dating provides absolute age estimates, enabling the temporal placement of archaeological contexts or samples, but the reliability, accuracy, and precision of radiocarbon dates can vary. Correspondence analysis primarily deals with categorical variables such as artefact types or features, which operate at a qualitative level. The disparate nature of these data types necessitates careful consideration of data quality, analytical methods and interpretive frameworks.

In this study the established CA visualized in a scatterplot was interpolated utilizing kriging, a geostatistical interpolation technique used to predict unknown values at specific locations based on known values from surrounding points. Kriging takes into account both the distance and the degree of variation between known data points to minimize prediction errors and provide an unbiased estimation with the least variance.⁵⁵ The available radiocarbon data were used as interpolated values to transform the relative chronological evaluation into absolute chronological data. Cokriging was applied using the radiocarbon data as a primary and the eigenvalues of the first axis as a secondary variable to refine the geostatistical interpretation.

2. Results

The uncalibrated ¹⁴C dates from Inzersdorf span from 3114 ± 30 BP to 2014 ± 36 BP (Tab. 1), representing a calibrated time frame from 1446 BC to AD 117 utilizing the 2σ interval (95.4 % certainty) or 1427 BC to AD 59 using the 1σ interval (68.3 % certainty). The dates cover a time span of 1563 or

46 RINGROSE 1992. – PORČIĆ 2013.

47 BØLVIKEN et al. 1982. – RINGROSE 1992.

48 HAMMER, HARPER, RYAN 2001.

49 MADSEN 2016.

50 KRIVORUCHKO, GRIBOV 2019.

51 KRIVORUCHKO, GRIBOV 2019.

52 GILLINGS, HACIGUZELLER, LOCK 2020, 118–134.

53 HAMMER, HARPER, RYAN 2001.

54 ILON 2015. – BÁNFFY et al. 2018. – WEBSTER 2021, 36–40. – WENINGER, KRAUSS 2024.

55 CHEENEY 1990. – BRADLEY, SMITH 2007. – GILLINGS, HACIGUZELLER, LOCK 2020, 118–134.

Sample ID	Sex	Age at death	Lab code	¹⁴ C Age BP $\pm \sigma$	Age cal BC (2 σ , 95.4 % probability)	Age cal BC (1 σ , 68.3 % probability)	Median calibrated calendar age
INZ106/II	undet.	1–6 yrs	RICH-32450	3114 $\pm$ 30	1446–1286 BC	1427–1311 BC	1386 BC
INZ248/I	female??	30–50 yrs	RICH-32437.1.1	3088 $\pm$ 30	1422–1276 BC	1411–1302 BC	1345 BC
INZ006/II	probably male	35–50 yrs	RICH-34138	3066 $\pm$ 27	1414–1236 BC	1391–1285 BC	1336 BC
INZ106/I	female??	> 20 yrs	RICH-31804	3049 $\pm$ 30	1404–1222 BC	1386–1263 BC	1312 BC
INZ017/II	undet.	3–9 mths	RICH-34140	3035 $\pm$ 27	1397–1213 BC	1379–1229 BC	1292 BC
INZ004/II	undet.	1.3–1.8 yrs	RICH-32443	3016 $\pm$ 25	1386–1131 BC	1369–1218 BC	1262 BC
INZ036	female??	> 20 yrs	RICH-31802	3000 $\pm$ 26	1378–1127 BC	1284–1134 BC	1239 BC
INZ039	undet.	20–50 yrs	RICH-34137	2995 $\pm$ 27	1376–1124 BC	1276–1132 BC	1231 BC
INZ170/I	male	35–44 yrs	RICH-32414.1.1	2993 $\pm$ 36	1386–1112 BC	1283–1128 BC	1228 BC
INZ041	male	> 20 yrs	RICH-32418.1.1	2992 $\pm$ 29	1376–1122 BC	1271–1130 BC	1226 BC
INZ094	female??	> 30 yrs	RICH-31806	2991 $\pm$ 25	1371–1124 BC	1267–1132 BC	1225 BC
INZ100	undet.	0–3 yrs	RICH-32419.1.1	2974 $\pm$ 26	1366–1059 BC	1258–1127 BC	1196 BC
INZ250	male??	30–50 yrs	RICH-34141	2970 $\pm$ 29	1283–1055 BC	1256–1126 BC	1188 BC
INZ061	male	20–50 yrs	RICH-32435	2970 $\pm$ 25	1277–1059 BC	1256–1127 BC	1188 BC
INZ260	undet.	14–19 yrs	RICH-32417	2967 $\pm$ 25	1271–1056 BC	1223–1126 BC	1182 BC
INZ251	male??	30–50 yrs	RICH-32441.1.1	2967 $\pm$ 28	1277–1055 BC	1224–1126 BC	1182 BC
INZ065	undet.	0–3 yrs	RICH-32413.1.1	2963 $\pm$ 26	1266–1055 BC	1221–1125 BC	1176 BC
INZ004/I	probably female	> 20 yrs	RICH-31800	2962 $\pm$ 26	1265–1055 BC	1220–1125 BC	1175 BC
INZ101	undet.	7–12 yrs	RICH-32438.1.1	2946 $\pm$ 26	1257–1051 BC	1212–1120 BC	1157 BC
INZ088	undet.	4–9 yrs	RICH-32424	2943 $\pm$ 24	1253–1051 BC	1210–1119 BC	1154 BC
INZ184	probably male	> 40 yrs	RICH-32444.1.1	2935 $\pm$ 29	1253–1018 BC	1210–1059 BC	1143 BC
INZ210/II	male	30–50 yrs	RICH-32445.1.1	2929 $\pm$ 28	1220–1017 BC	1200–1056 BC	1131 BC
INZ143	undet.	7–12 yrs	RICH-INZ 143	2928 $\pm$ 28	1220–1017 BC	1200–1055 BC	1129 BC
INZ032/II	female	> 20 yrs	RICH-32449	2918 $\pm$ 25	1212–1017 BC	1192–1052 BC	1111 BC
INZ027/II	undet.	> 20 yrs	RICH-32440	2917 $\pm$ 26	1211–1016 BC	1191–1051 BC	1110 BC
INZ075	male??	30–50 yrs	RICH-31805	2914 $\pm$ 26	1206–1016 BC	1190–1050 BC	1105 BC
INZ162	undet.	4–6 yrs	RICH-32420	2910 $\pm$ 26	1205–1013 BC	1188–1048 BC	1098 BC
INZ258/I	female	> 40 yrs	RICH-32427	2907 $\pm$ 24	1202–1012 BC	1155–1020 BC	1093 BC
INZ029/II	undet.	0–19 yrs	RICH-32416	2900 $\pm$ 25	1201–1008 BC	1122–1019 BC	1084 BC
INZ120	male	20–50 yrs	RICH-32446	2876 $\pm$ 24	1187–935 BC	1110–1010 BC	1051 BC
INZ083	ambig.	20–50 yrs	RICH-32625	2867 $\pm$ 21	1120–935 BC	1107–1004 BC	1037 BC
INZ163	male	30–50 yrs	RICH-32428.1.1	2849 $\pm$ 28	1111–926 BC	1051–933 BC	1009 BC
INZ314	female??	30–50 yrs	RICH-32448	2843 $\pm$ 25	1108–921 BC	1047–933 BC	999 BC
INZ006/I	female?	> 20 yrs	RICH-31807	2839 $\pm$ 25	1107–917 BC	1044–932 BC	993 BC
INZ029/I	male??	20–40 yrs	RICH-34139	2835 $\pm$ 36	1111–906 BC	1045–928 BC	991 BC
INZ192	male??	40–69 yrs	RICH-31801	2832 $\pm$ 26	1105–907 BC	1014–931 BC	984 BC
INZ205	female??	> 20 yrs	RICH-32432	2832 $\pm$ 24	1055–908 BC	1014–931 BC	983 BC
INZ220	female??	30–50 yrs	RICH-32436	2794 $\pm$ 25	1012–845 BC	984–908 BC	949 BC
INZ171	undet.	7–12 yrs	RICH-32423	2786 $\pm$ 25	1008–841 BC	983–902 BC	936 BC
INZ197	probably male	> 20 yrs	RICH-32415.1.1	2784 $\pm$ 25	1007–840 BC	983–901 BC	932 BC
INZ170/II	undet.	8–11 yrs	RICH-32422.1.1	2776 $\pm$ 26	1003–836 BC	978–847 BC	920 BC
INZ175	female	> 20 yrs	RICH-31803	2776 $\pm$ 26	1003–836 BC	978–847 BC	920 BC
INZ003/I	undet.	> 20 yrs	RICH-32425.1.1	2775 $\pm$ 29	1002–835 BC	979–843 BC	919 BC
INZ194	male??	20–69 yrs	RICH-32429.1.1	2769 $\pm$ 32	1002–832 BC	974–838 BC	911 BC
INZ032/I	probably male	30–50 yrs	RICH-32447	2753 $\pm$ 24	977–826 BC	920–836 BC	881 BC
INZ202/I	ambig.	30–50 yrs	RICH-32451	2741 $\pm$ 23	928–821 BC	906–834 BC	870 BC
INZ017/I	female??	35–45 yrs	RICH-32430	2635 $\pm$ 23	827–784 BC	811–794 BC	804 BC
INZ182	male??	> 20 yrs	RICH-32426.1.1	2525 $\pm$ 28	791–544 BC	777–570 BC	644 BC
INZ106/III	undet.	9–13 yrs	RICH-32434.1.1	2014 $\pm$ 36	102 BC–AD 117	47 BC–AD 59	2 BC

Tab. 1. All 49 calibrated ¹⁴C results sorted by median. The three-digit number after INZ indicates the grave number; in graves with multiple occupation I, II or III refers to the individual.

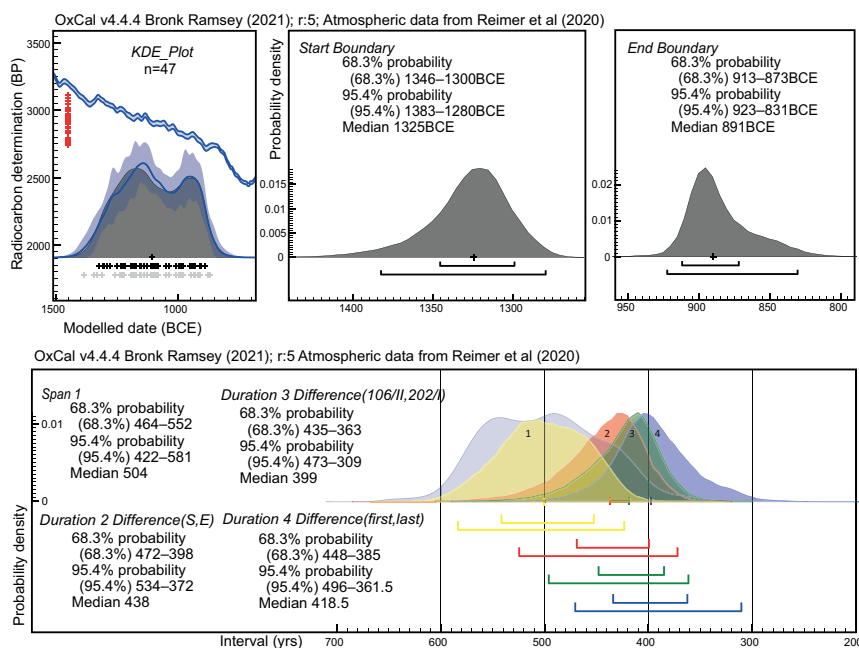


Fig. 3. Model of the duration of cemetery occupation at Inzersdorf using various variables in the *difference()* function. – Upper left: Start and end boundary. – Upper middle: First and last. – Upper right: The oldest and youngest calibrated dates (106/II and 202/I). – Bottom: All durations stacked in one timeline.

1486 years, respectively.⁵⁶ Forty-seven of the 49 samples fall within the expected time frame of the Late Middle Bronze Age to the Early Urnfield period. Two samples (INZ182 and INZ106/III), however, are entirely outside the time period and will be discussed separately.

2.1. Chronological Modelling of ¹⁴C Dates

To analyse the duration of use of the burial site, a kernel density model (KDE) was created in OxCal4.4. In order to statistically estimate both the start and the end of the occupation of the burial site, the tools *boundary* and *σ-boundary* were used. For the duration of the cemetery use, the functions *span()* and *difference()* were applied, the latter with three different parameters: first, the oldest and the youngest ¹⁴C dates; second, the boundaries; and third, the first and the last grave.⁵⁷

The KDE reveals that the occupation of the burial site began around the transition from the Middle Bronze Age to the Early Urnfield period (around 1400 BC), then its use sharply increased, reaching its peak during the Early Urnfield period in around 1200 BC to 1100 BC. There was a slight decline in activity after this period, with another,

smaller peak around the transition to the Late Urnfield period (around 1000 BC to 900 BC).

The boundary indicates that the beginning of the burial site dates between 1383 BC and 1280 BC, 2σ, or 1346 BC to 1300 BC, 1σ, while the end falls between 923 BC and 831 BC, 2σ or 913 BC to 873 BC, 1σ. Depending on the parameters used to estimate the duration of the burial site's occupation, the results vary slightly (Fig. 3). Using the *span()* function, the occupation period is estimated between 422 and 581 years, with a median of 504 years, which can be considered the likely maximum duration of the burial site's use. Using the start and end boundaries with the *difference()* function, the duration is between 372 and 534 years, with a median of 438 years. The duration is shorter when based on the first and last graves, resulting in 361.5 to 496 years, with a median of 418.5 years. The shortest duration is obtained using the parameters INZ106/II and INZ202/I, which represent the earliest and latest ¹⁴C dates, with a range of 309 to 473 years and a median of 399 years. This leads to an estimated duration of the cemetery's use of approximately 400 to 500 years.

2.2. Geostatistical Modelling of ¹⁴C Dates

Geostatistical modelling was employed to analyse if graves of similar dates are located close to each other and to reconstruct the spatial sequence of burials. The empirical semi-variances of the ¹⁴C data and, despite some deviations, the general trend

⁵⁶ REIMER et al. 2020.

⁵⁷ BRONK RAMSEY 2009. – BRONK RAMSEY 2017.

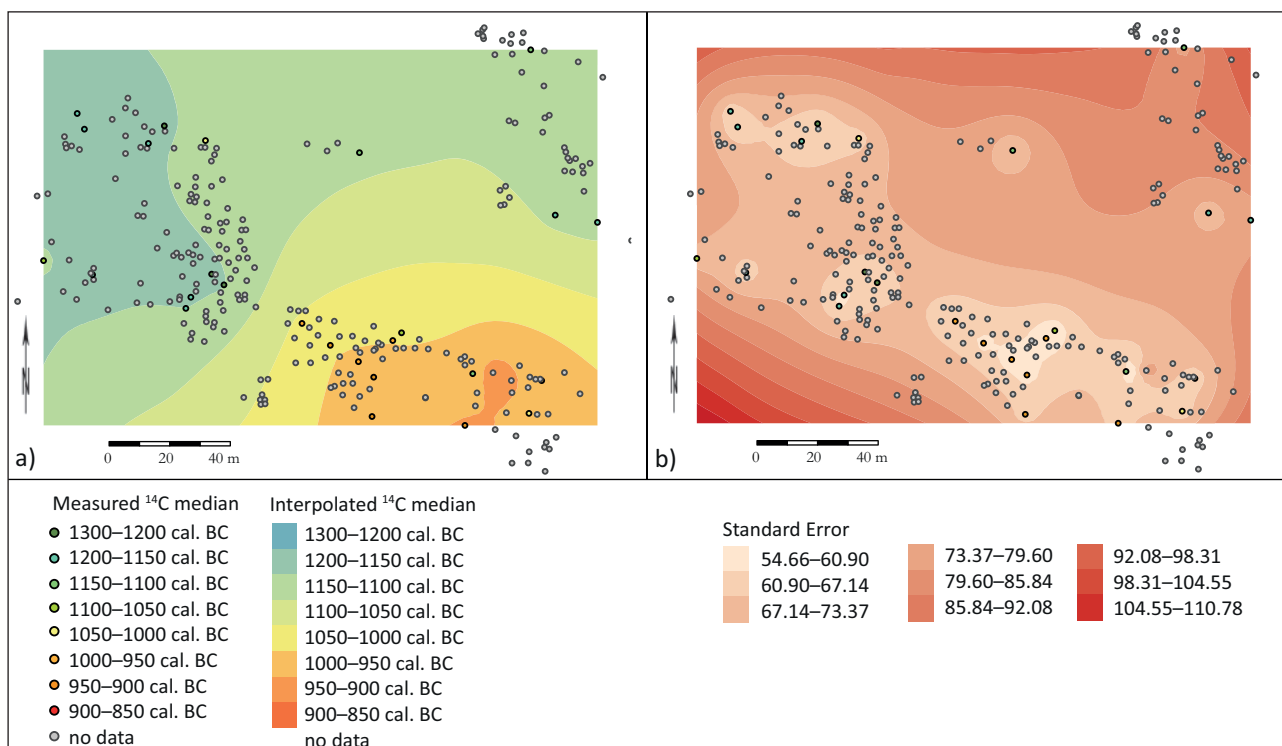


Fig. 4. Empirical Bayesian kriging interpolation and standard error of the empirical Bayesian kriging interpolation of the ^{14}C -dated individuals.

indicate a more or less positive autocorrelation, suggesting that geographically closer graves tend to have similar ^{14}C values compared to those that are farther apart⁵⁸ (see Appendix 2 for semi-variogram and regression graph⁵⁹).

The empirical Bayesian kriging (EBK) interpolation shows that the oldest graves are located in the western part of the cemetery (Fig. 4). From this point, there is a continuous progressive occupation of the cemetery toward the east and southeast. The occupation of the northeastern part of the cemetery remains unclear due to the lack of available data from destroyed parts of the cemetery.

These results are subject to significant uncertainty, as seen in the standard error of the prediction (Fig. 4b). The root mean square standardized error (RMSSE), which measures how well the prediction fits, shows a value of 0.96, confirming that the standard errors have been calculated satisfactorily and the model is reliable (the optimal value is 1).

2.2.1. Correspondence Analysis

The initial seriation and correspondence analysis were based on 136 graves in order to retain as many graves as possible

for which strontium isotope data is available in the sample.⁶⁰ At this point, the analysis included graves with little material, often belonging to children or individuals from marginalized groups that we assume to be the lower strata of society, represented by burials to which little attention or effort was paid. Their exclusion would have introduced a social bias into the subsequent analyses, which aimed to consider all groups. However, this decision compromised the chronological significance of the findings. To improve chronological accuracy, additional rounds of analysis based on 76 graves were performed, removing the burials with minimum information value (Fig. 5). As a measure of quality, the final criterion was 0.35. The recommended value of 0.7 to 0.8 for establishing a relative chronological interpretation⁶¹ was not achieved, but trends can still be inferred.

To test the validity of the correspondence analysis, a rank comparison was conducted between the median of the ^{14}C analyses and the rank derived from the eigenvector of the first axis using Spearman's r .⁶² For this purpose, the data was reduced to graves that were utilized in both analyses. Further, graves that contained multiple individuals were

⁵⁸ TOBLER 1970. – BRADLEY, SMITH 2007.

⁵⁹ Supplementary figures and model diagnostics are available as Online Appendix 2: doi: 10.1553/archaeologia109s177-A2.

⁶⁰ FRITZL et al. 2024.

⁶¹ THEUNE 1995. – STADLER 2005.

⁶² PRESS et al. 1992, 629.

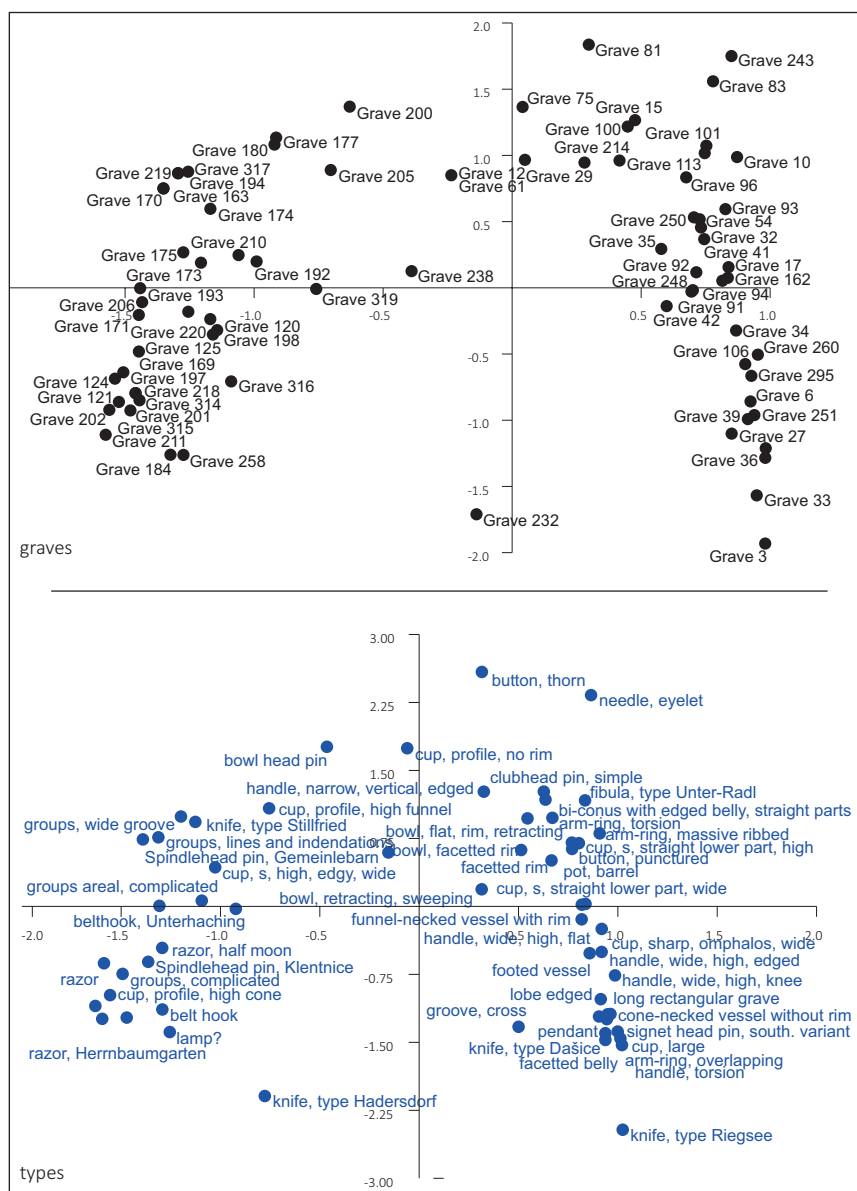


Fig. 5. Scatterplot of the correspondence analysis. – Above: Graves. – Below: Types.

excluded, as these exhibited a large variance in the ^{14}C results. The Spearman's rank correlation yielded a value of -0.73355 , which indicates a strong negative correlation ($p < 0.001$, $n = 31$). This means that the age increases significantly as the eigenvector value rises.

2.2.2. Geostatistical Modelling of Correspondence Analysis Dates

The empirical semi-variances of the correspondence analysis data show that almost all values, with the exception of the first three data points, fall outside the 25th to 75th percentiles. The data shows a strong correlation between distance and similarity in the regression graph ($p < 0.001$, $r = 0.847$;

$\text{slope} = 0.79$, $p(\text{slope}) = 3.5332\text{E}-21$). Upon closer examination, however, two data clusters become apparent in the regression analysis. When those are analysed separately, the lower cluster shows a positive correlation ($p = 0.0117$, $r = 0.4356$) between distance and age ($\text{slope} = 0.75478$, $\text{standard error} = 0.26364$, $p(\text{slope}) = 0.007$) while the upper cluster shows no correlation ($p = 0.8794$, $r = 0.0249$; $\text{slope} = 0.03995$, $\text{standard error} = 0.27494$, $p(\text{slope}) = 0.885$). Despite some deviations, the general trend still shows autocorrelation. Only the graves exhibiting negative eigenvalues and that are geographically closer, however, tend to exhibit more similar values compared to graves located farther apart (see Appendix 2).

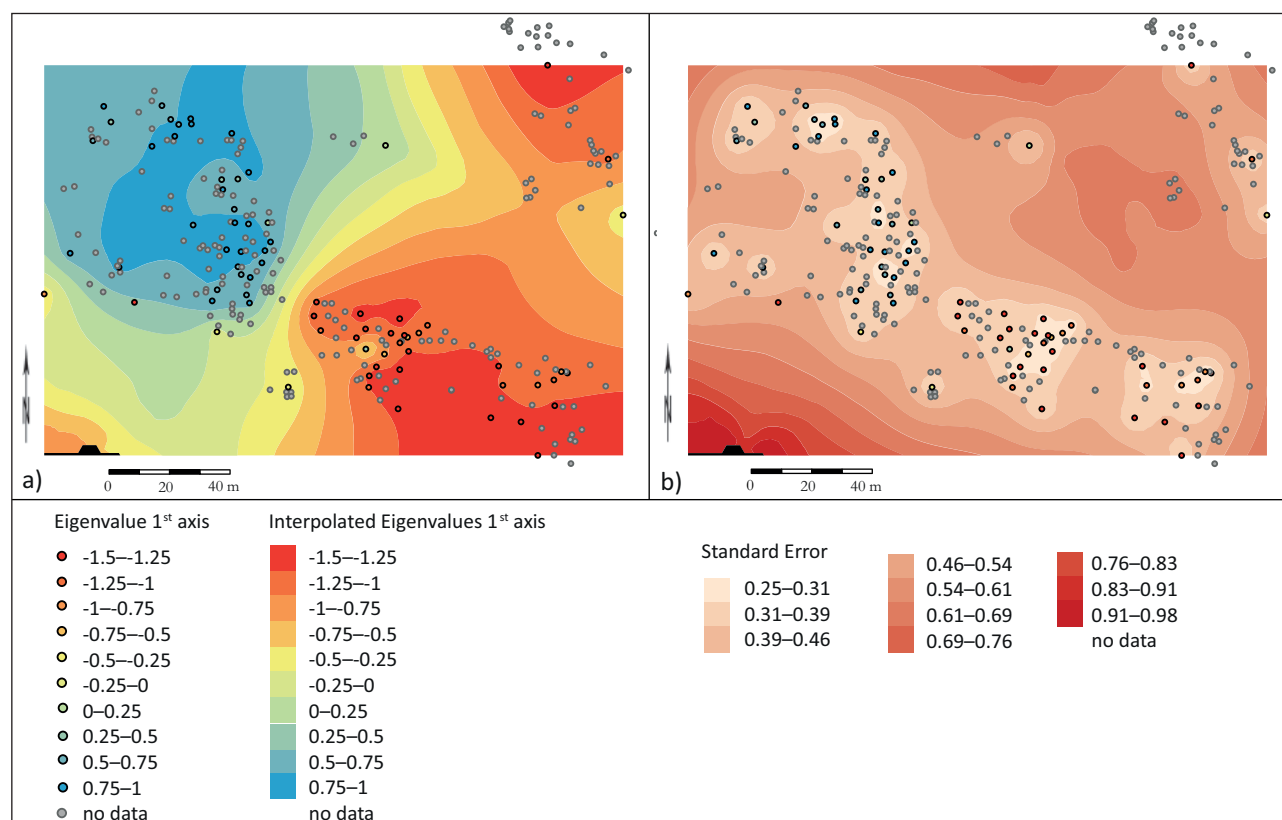


Fig. 6. Empirical Bayesian kriging interpolation and standard error of the empirical Bayesian kriging interpolation of the correspondence analysis data.

The resulting empirical Bayesian kriging (Fig. 6a) interpolation shows that the oldest graves are located in the western part of the cemetery, with a continuous progressive occupation of the field moving eastward. Unlike the interpolation based on ^{14}C data, the northeastern part of the cemetery is here attributed to the younger phase. Similar to the ^{14}C data model, this can be explained by the limited data available. In addition, the preservation in this area was particularly poor, resulting in few diagnostic finds, making its integration into the correspondence analysis difficult. As a result, the standard error for this area is relatively high (Fig. 6b). The two EBK models thus largely agree, with the exception of the northeastern corner of the cemetery.

2.3. Merging Correspondence Analysis and Radiocarbon Data

2.3.1. Combined Model

A finer resolution can be achieved when both models are combined, using cokriging with the ^{14}C median as the primary variable and the 1st axis of the CA as the secondary variable. Not only do the predicted data points align better with the measured ones, as shown in the co-variogram

and semi-variogram graphs, but the overall model performance is also enhanced (see Appendix 2). Additionally, the average standard error improves to 95.44 (compared to 115.85 in the ^{14}C EBK), and the RMSSE is closer to 1, reaching a value of 1.002.

In the combined model (Fig. 7), the western area reveals a central point that likely contained the oldest graves (1240–1200 BC) in the cemetery. This area is surrounded by graves dating to around 1200–1150 BC. The transition to the later phase of the cemetery remains unclear and likely falls within the destroyed section of the burial site. The combined model also provides better clarification for dating the northeastern area, suggesting a probable range between 1150 and 1050 BC, with a relatively high standard error. The occupation of the eastern section of the cemetery begins around 1050 BC, with a gradual shift eastward, until burial activity ceases around 900 BC.

2.3.2. Interpolating Correspondence Analysis Data

Another method to test the quality of the correspondence analysis was to perform kriging based on the ^{14}C dates. For this, the scatter plot of the correspondence analysis was

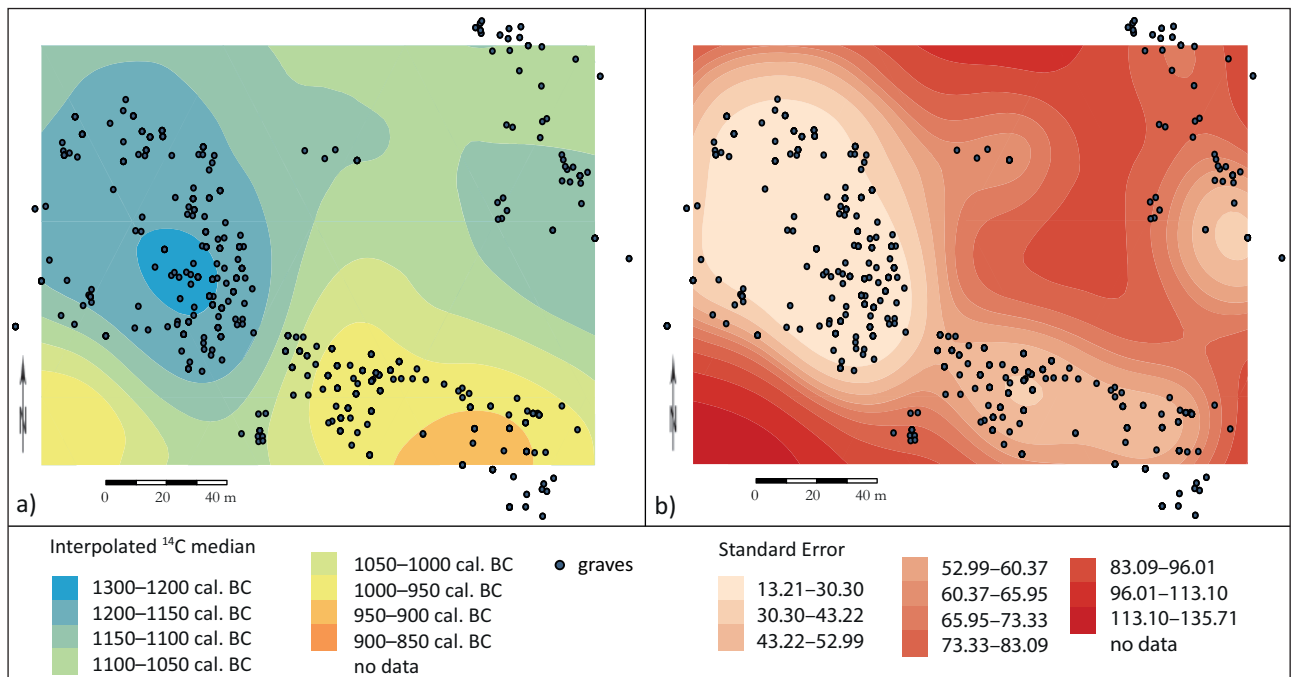


Fig. 7. Cokriging interpolation and standard error of the Cokriging interpolation of the ^{14}C data (primary) and correspondence analysis data (secondary).

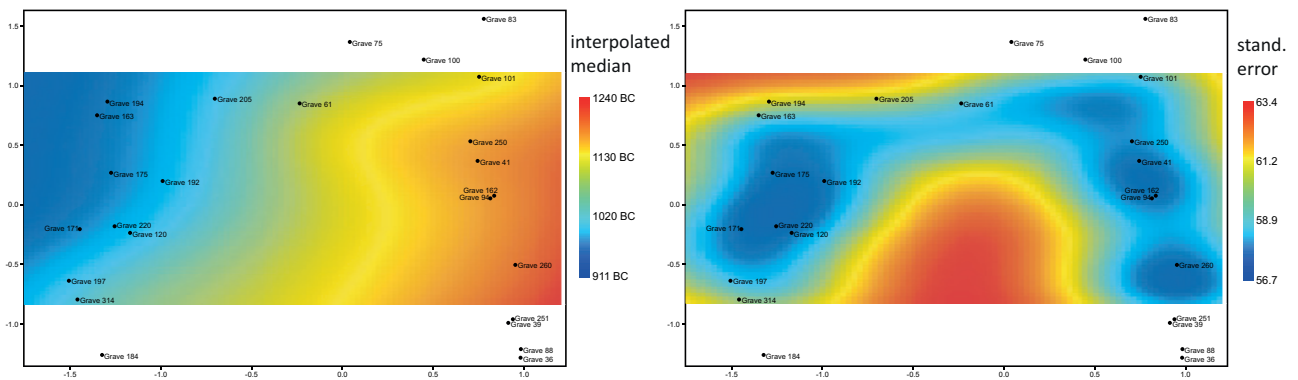


Fig. 8. Ordinary kriging interpolation of the correspondence analysis scatterplot based on ^{14}C data. – Left: Interpolation. – Right: Standard error.

reduced to the graves for which ^{14}C data were available, and then kriging was conducted based on the radiocarbon data. The interpolated model shows a clear progression along the curve, although a few uncertainties are included (Fig. 8). Particularly in the area of the later graves (blue areas), there is increasing fuzziness, as the progression does not precisely follow the curve. However, the curve becomes much clearer in this area when looking at the plot of the standard errors. Only a slight fuzziness is seen to the left of the centre, which can be attributed to the fact that there are fewer data points in this area. The normalized

root mean square error (NRMSE) for this model is 0.059, which is a relatively good value (0 would be optimal),⁶³ especially when considering the original criterion of the correspondence analysis of 0.35, which would be insufficient proof. This approach allowed the identification of chronologically significant pottery and bronze artefact types by radiocarbon-dated graves.

⁶³ HASTJE, TIBSHIRANI 1990, 352. – SOHIL, SOHAIL, SHABIR 2022.

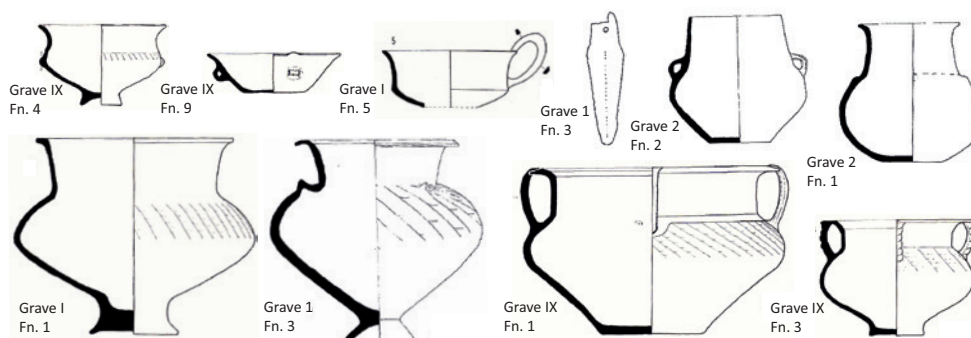


Fig. 9. The type-chronological spectrum of ceramic and bronze finds from the cemetery of Getzersdorf (after KAUS 1971 and GROISS 1976).

3. Discussion

3.1. Chronological Contextualisation with Other Sites in the Region

3.1.1. Older than Old ...

The start of the use of the urnfield of Inzersdorf was modelled using the boundary function, ranging from 1383 BC to 1280 BC. This indicates that the beginning potentially extends to the Middle Bronze Age and no later than the earliest Urnfield period. A significant rise in burial activity starts around 1300 BC, a trend that continues until approximately 1200/1150 BC. According to the relative chronological framework, this phase corresponds to BA D and the early phase of Ha A1. The burial activity therefore begins earlier than previously assumed. The oldest grave is Grave 106, which contains three individuals (106/I, 106/II and 106/III), two of whom can be securely attributed to the grave context, while the third remains a matter of debate. Along with the other long rectangular graves from Inzersdorf, this multiple grave with a ceramic drum has been typo-chronologically dated to the early phase of Ha A1.⁶⁴

The cemetery of Getzersdorf, only a few hundred metres farther north of Inzersdorf, was primarily dated to BA D, extending into Ha A.⁶⁵ A temporal succession from Getzersdorf to Inzersdorf has been suggested, potentially indicating a relocation of the burial site. The cemetery of Getzersdorf consists exclusively of long rectangular graves, which show a strong connection to the Middle Bronze Age, just like the oldest graves at Inzersdorf.⁶⁶ The typological spectrum alone did not offer a fine enough temporal resolution to determine whether the earliest graves from Inzersdorf are later or contemporary with those of Getzersdorf (Fig. 9).

Excavations at the cemetery of Getzersdorf date back to the beginning and middle of the 20th century,⁶⁷ and significant quantities of the documentation, finds and cremated remains have been lost or can no longer be contextualized. Only the cremated human remains from one grave were conclusively attributed; sample GTZ1 corresponds to Grave 3.⁶⁸ It is not even certain that this grave was a long rectangular grave, as the documentation only recorded a 'wide-bellied urn with cremated remains'. In addition, two radiocarbon samples were taken from human bones that could not be assigned to a specific grave but are believed to have come from the Ha A-period cemetery of Getzersdorf. The results range from 923 to 814 BC, 2 σ , in the contextualized sample and 1214 to 1014 BC, 2 σ , in the two other samples (Tab. 2), indicating that the oldest graves at Inzersdorf Cemetery are older than those at Getzersdorf and that the two cemeteries were at least partially contemporaneous.

Since the earliest graves from Inzersdorf date earlier than initially assumed, it becomes necessary to consider them in the context of the transition from the Middle Bronze Age to the Early Urnfield period. The recently published radiocarbon data from the burial mounds with door openings used for burials in multiple phases from Unterradlberg provide a valuable comparison, as they reveal remarkably similar dates. Unterradlberg and Inzersdorf are only seven kilometres apart.⁶⁹ The earliest radiocarbon-dated element ranges from 1400 to 1190 BC, 2 σ (Verf. 818, Indiv. II). A second date taken from the same grave but a different individual (Verf. 818, Indiv. I) shows a time span from 1300 to 1120 BC, 2 σ . The youngest radiocarbon date from Unterradlberg ranges from 1220 to 1010 BC, 2 σ (Verf. 742), covering the entire time span of the earlier Urnfield period. Due to the

⁶⁴ LOCHNER 2013. – LOCHNER 2015.

⁶⁵ KAUS 1971. – LOCHNER 2013.

⁶⁶ LOCHNER 2013.

⁶⁷ KAUS 1971. – MAURER 1971. – GROISS 1976.

⁶⁸ GROISS 1976.

⁶⁹ SKERJANZ 2024, 16.

Sample ID	Location in the grave	Lab code	¹⁴ C Age BP ± σ	Age cal BC (2σ, 95.4 % probability)	Age cal BC (1σ, 68.3 % probability)	Median calibrated calendar age
GTZ4	unknown	RICH-31795	2920 ± 28	1214–1016 BC	1195–1051 BC	1115 BC
GTZ5	unknown	RICH-31792	2910 ± 25	1203–1014 BC	1188–1048 BC	1098 BC
GTZ1	In the urn	RICH-31794	2729 ± 27	923–814 BC	899–832 BC	867 BC

Tab. 2. Calibrated ¹⁴C dates from Getzersdorf.

large confidence intervals, definitive conclusions cannot be drawn. Nevertheless, it seems highly likely that Unterradlberg and Inzersdorf were at least partially contemporaneous and followed different burial traditions at the same time.

Recently published radiocarbon data from two urn graves in the St. Pölten area, located only 15 km south of Inzersdorf, offer further insights.⁷⁰ The samples date from 1430 to 1280 BC and 1420 to 1260 BC respectively, surprisingly early for this burial type. Statistically, however, it is possible to establish a sequence from Middle Bronze Age Unterradlberg to Inzersdorf and St. Pölten and the associated Early Urnfield period.

However, this introduces new discussion points regarding the chronological positioning and sequence of BA D and Ha A1. On the one hand, Ha A1 could date significantly earlier than previously assumed, while BA D might have persisted longer or gradually transitioned to Ha A1. It is therefore possible that multiple traditions coexisted in this small region, both in terms of burial practices and typological forms, which represent a distinctly broad chronological spectrum of finds.

3.1.2. ... and Later than Late

Franzhausen-Kokoron, located just four kilometres north of Inzersdorf, is of interest in regard to the later use of Inzersdorf as a burial ground. Due to the typo-chronological spectrum, it has been assigned to the Later Urnfield period,⁷¹ giving rise to the assumption that Franzhausen-Kokoron chronologically succeeded Inzersdorf. However, radiocarbon data from Inzersdorf reveal that several graves (Tab. 1) date considerably later in the Urnfield Period, with a few, such as Grave 182, even dating to the Iron Age. A closer analysis of the cemetery's latest phase reveals types such as collared bowls (e.g. 171/03, Fig. 12) that clearly indicate the beginning of the Hallstatt period.⁷²

This suggests that the use of the cemetery of Inzersdorf did not end abruptly, but instead gradually declined. The typo-chronological spectrum also reveals clear connections to the Later Urnfield period, particularly through the presence of collared bowls (e.g. 171/03), specific decoration styles such as hanging arches and extensive decoration filling the upper part of entire vessels (e.g. 120/01, Fig. 12) and knives of the Hadersdorf (e.g. 184/06, Fig. 11) or Stillfried type (e.g. 173/03, Fig. 11). The chronological end of the cemetery is modelled between 926 and 826 BC, 2σ, indicating that the cemetery may date significantly later than previously thought in some parts. Consequently, an overlap in the use of Inzersdorf and Franzhausen-Kokoron must be considered.

3.2. Cemetery Structure

Grave 106 (Fig. 10), the most prominent grave in the entire cemetery, is unique in more than one respect: it contained three individuals, two of whom were found in long, oval features at the bottom of a square grave pit (106/I and 106/II). The original location of the third individual (106/III) is unclear from the sparse documentation, it seems to have been found either in the grave fill or mixed with the other cremated remains.⁷³ Similar graves in southern Germany⁷⁴ have often been interpreted as 'founder's graves', referring to their comparatively old-fashioned material culture in their respective contexts.⁷⁵ For example, the strikingly similar grave structure at Zuchering-Ost contained the remains of 13 individuals, and it is thought to be the oldest grave of the cemetery.⁷⁶

All three individuals from Inzersdorf Grave 106 have been radiocarbon dated. While the first two individuals make it indeed the oldest documented grave of the cemetery (106/I: 1404–1222 BC, 2σ; 106/II: 1446–1286 BC, 2σ), the third individual (106/III) dates to the Roman Imperial period (Individual 106/III: 102 BC – AD 117). Due to the unclear context, it seems likely that this individual represents a later intrusion, perhaps indicated by a disturbance in the

⁷⁰ WALTENBERGER et al. 2023.

⁷¹ LOCHNER, HELLERSCHMID 2016.

⁷² SEEGER-KNEUSSL 1990, 134–136 and Pl. 2. – LIPPERT, STADLER 2009, 73–77, 106. – GRIEBEL, BIEDERER 2022, 38, 106. – LAUERMANN, LINDINGER, HASENHÜNDL 2022, 30, 37, 45, 50, 153, 177.

⁷³ FRITZL 2017, 401–421.

⁷⁴ WIESNER 2009, 80.

⁷⁵ WIRTH 1999. – SCHÜTZ 2007, 237–242. – PRIMAS 2008, 76–77. – KRAPF 2010.

⁷⁶ SCHÜTZ 2007, 237–242. – KRAPF 2010.

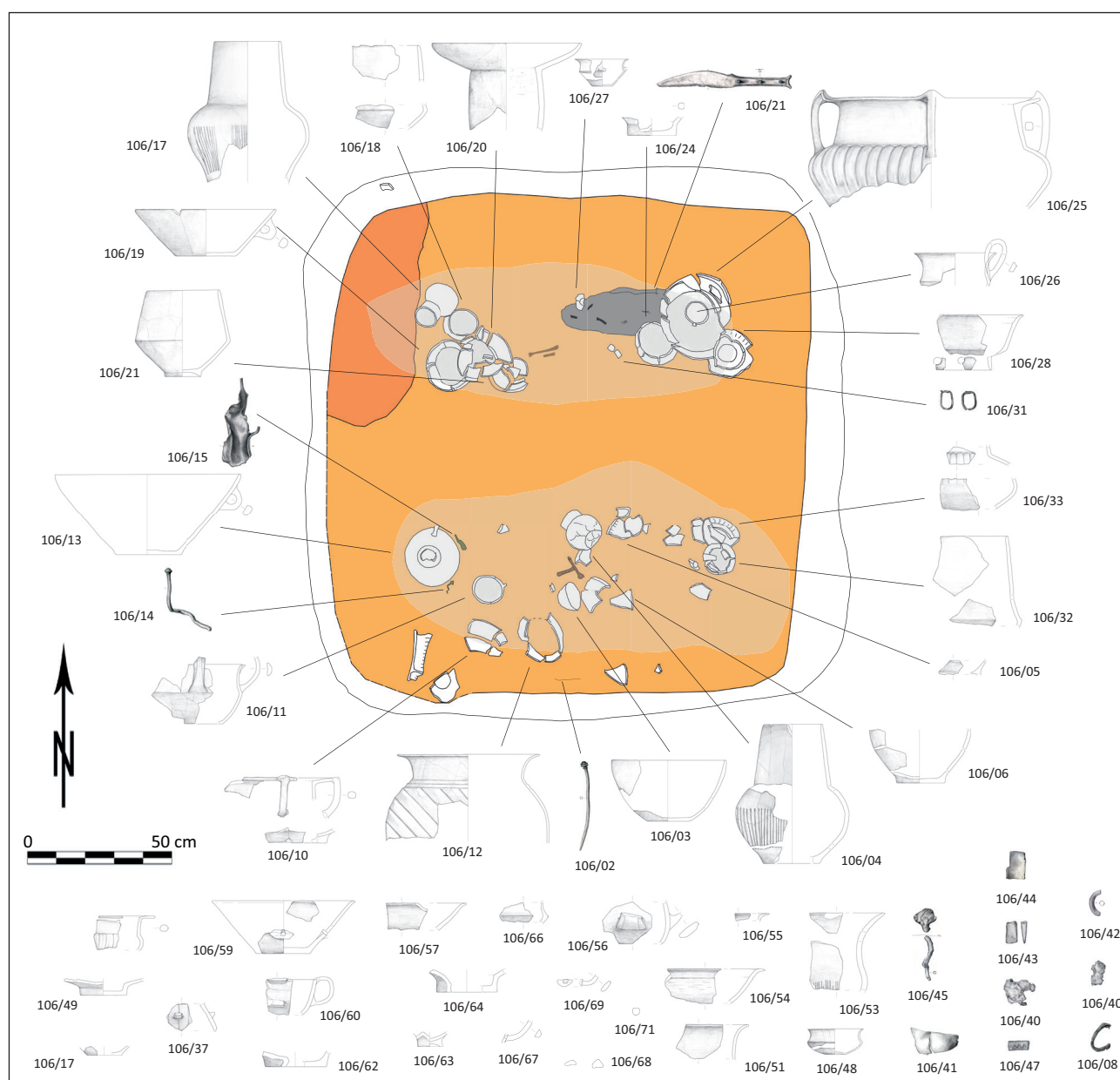


Fig. 10. Grave 106 and the finds for which a precise location could be identified in the parallel rectangular burial features.

southern area of the grave.⁷⁷ It is possible that the use of this particularly outstanding grave had a symbolic significance in terms of the appropriation or appeal to ancient traditions. Burials, especially tumuli, have frequently been reused after an extended period⁷⁸ as a means to legitimize claims of place

and rulership.⁷⁹ For such a practice the grave would have to be recognizable above ground in antiquity, which could not be directly inferred from the excavation data.

3.3. Interpolated Chronology

Different occupation phases of the cemetery can be identified in the interpolated plot of the correspondence analysis and further correlated with typologically significant

⁷⁷ LOCHNER 2015.

⁷⁸ KAUS 1993–1994. – DOBIAT 1994, 66–79. – MÜLLER-SCHESSEL 2009a. – MÜLLER-SCHESSEL 2009b. – FALKENSTEIN 2017. – SCHUMANN et al. 2023, e.g. 33–43, 75–93, 95–107, 109–120, 121–132, 133–145.

⁷⁹ HAHN 2004. – PRIMAS 2008, 77–78. – MÜLLER-SCHESSEL 2009a. – STOCKHAMMER 2011.

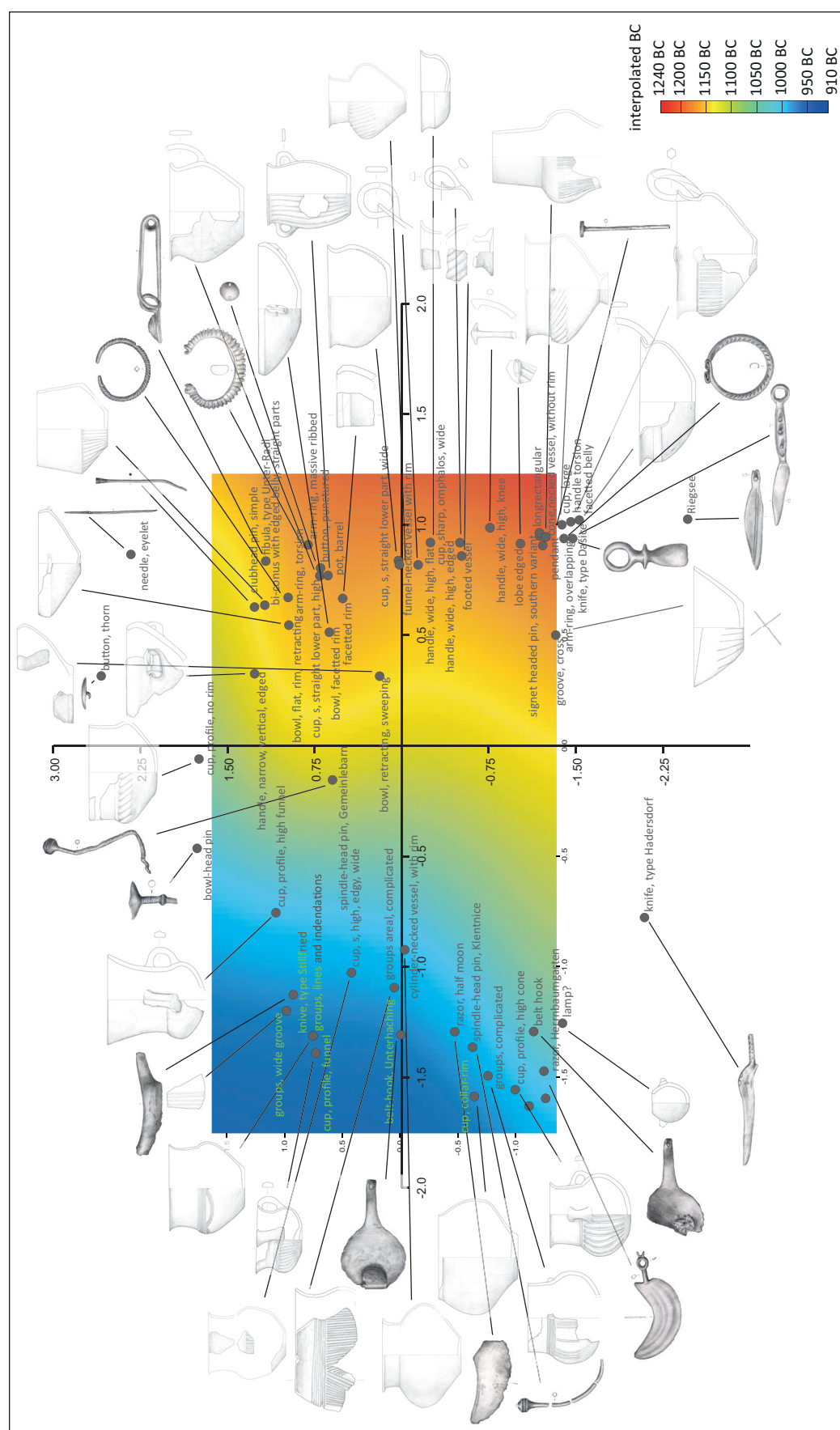


Fig. 11. Ordinary kriging interpolation of the correspondence analysis scatterplot based on ^{14}C data. Each point represents an artefact type inferred by the correspondence analysis merged with the interpolated absolute date derived from the individuals. This graph visualizes the connection between the absolute dates and ceramic and small finds significant for the relative chronology.

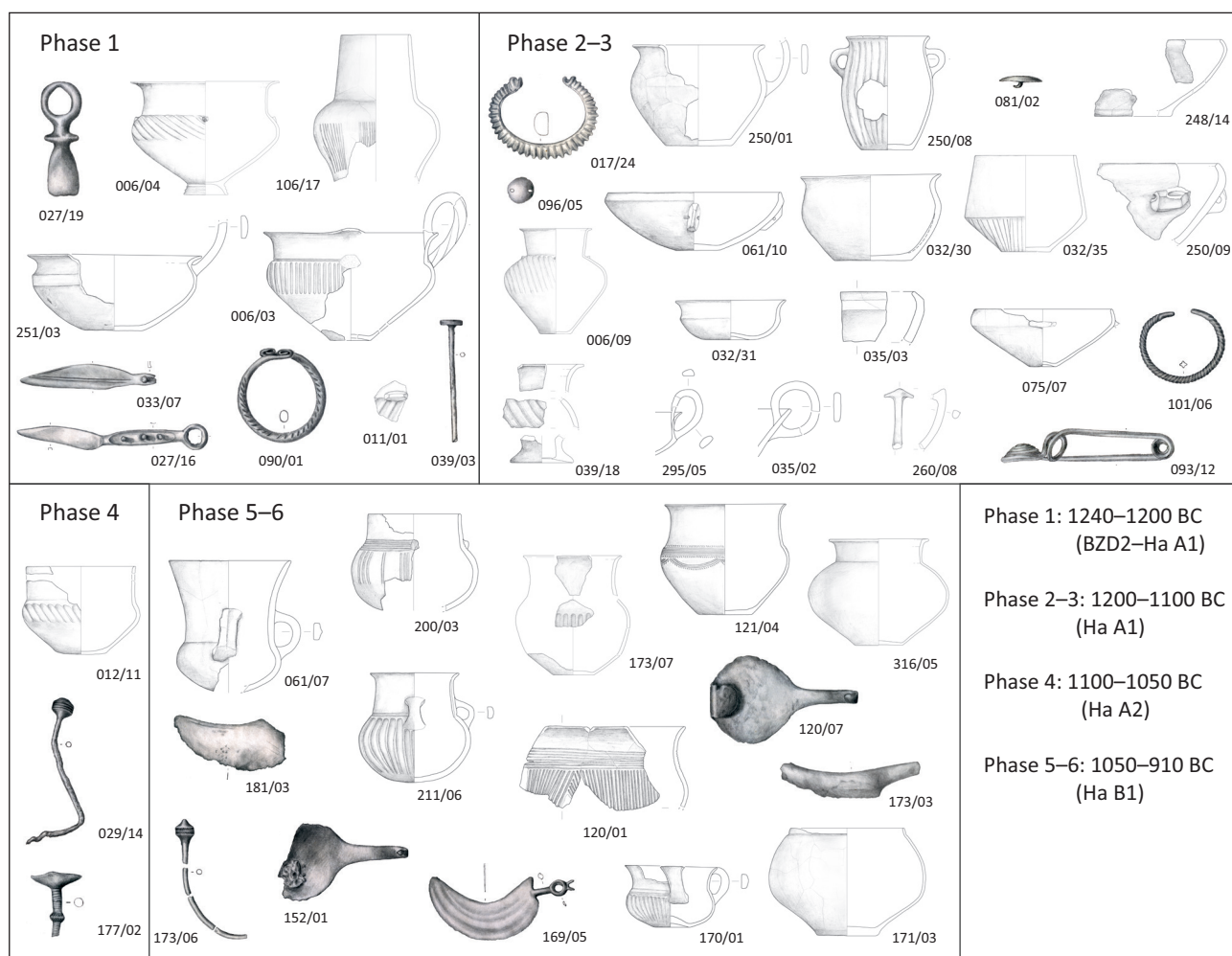


Fig. 12. Chronologically significant finds of each occupation phase (not to scale).

markers of absolute chronology (Figs. 11–12). This allows for an unusually detailed subdivision of the Urnfield period, offering a finer chronological structure than is typically achievable for this era.

The results from the graves with multiple occupation (Tab. 3) evidence significant discrepancies between the radiocarbon dates of different individuals and suggest that each individual burial needs to be discussed separately. To prevent data distortion, these graves have been excluded from the chronological analysis of the cemetery as a whole. Graves with multiple occupation predominantly appear in the earliest phase of the cemetery and include the five oldest radiocarbon dates of the cemetery. This phase is represented by a median ^{14}C date of 1240 BC, whereas the oldest radiocarbon date, from Individual 106/II, ranges from 1446 to 1286 calBC. However, due to limited data, this early period cannot be more precisely delineated at this point.

3.3.1. Phase 1: The Initial Phase 1240–1200 BC

One end of the typo-chronological spectrum, with a median ^{14}C range from 1240 BC to 1200 BC, is characterized by items such as pins with simple signet heads of the southern variant (e.g. 039/03, Fig. 12). According to Lochner,⁸⁰ these can be dated to the Earlier Urnfield period, while Říhovský⁸¹ does not provide a precise date. The knife of the Dašice type (027/16, Figs. 11–12) also belongs to the Early Urnfield period, as noted by Říhovský⁸² and Lochner.⁸³ Further notable bronze finds in this group are bracelets with overlapping ends (e.g. 090/01, Fig. 12), which show ties to

⁸⁰ LOCHNER 1991a, 172, 175–176. – LOCHNER 1991b.

⁸¹ ŘÍHOVSKÝ 1979, 46–54.

⁸² ŘÍHOVSKÝ 1972, 34–36.

⁸³ LOCHNER 1991b, 201–205.

the Čaka group,⁸⁴ and anthropomorphic pendants (e.g. 027/19, Figs. 11–12).⁸⁵

The typo-chronological spectrum of ceramics of this phase includes large profiled cups (e.g. 006/04 Fig. 12), conical-necked vessels without shaped rim (e.g. 106/17, Fig. 12), strap handles with sharp bends (e.g. 260/08, Fig. 11), vessel walls with a faceted profile (e.g. 251/03, Fig. 12), and elaborately shaped knobs (e.g. 011/01, Fig. 12). These features retain craft traditions from the Middle Bronze Age (compare Pitten, Getzersdorf, Baierdorf⁸⁶), but are clearly part of the Earliest Urnfield period. This initial occupation phase of the cemetery aligns with the BA D to HaA1, with an absolute dating median of 1240–1200 BC.

3.3.2. Phases 2 and 3: The First Peak Phases 1200–1150 BC and 1150–1100 BC

The cemetery shows an initial peak in its occupation between approximately 1200 BC and 1100 BC, as evidenced in both the kernel density estimation and the correspondence analysis (Fig. 3). In the interpolated correspondence analysis plot, this phase can be further divided into two segments: 1200–1150 BC and 1150–1100 BC.

Phase 2 (1200–1150 BC) is characterized by specific ceramic types, such as footed vessels (e.g. 039/18, Fig. 12), strap handles reaching over the vessel rim with triangular or flat cross-sections (e.g. 295/05, Fig. 12), cups with a sharp profile (e.g. 032/31, Fig. 12), funnel-necked vessels with rim shaping (e.g. 006/09, Fig. 12) and cups with straight lower sections and faceted rims (e.g. 035/03, Fig. 12). Bronze finds from this phase include twisted bracelets (e.g. 101/06, Fig. 12) and massive ribbed bracelets (e.g. 017/24, Fig. 12). Those finds are not necessarily considered highly chronologically significant by themselves, but can be placed in the Ha A phase.⁸⁷

Phase 3 (1150–1100 BC) is marked by ceramics such as flat-bottomed bowls with an inward-curving rim (e.g. 075/07, Fig. 12), perforated handle flaps (e.g. 250/09, Fig. 12), double-conical vessels with straight walls (e.g. 032/35, Fig. 12) and curved bowls with inward-bent rims (e.g. 061/10, Fig. 12). These ceramic types reflect the typical spectrum of the Early Urnfield period.⁸⁸ Bronze finds include fibulae of the Unter-Radl type (e.g. 093/12, Fig. 12) and simple club-headed pins (e.g. 250/04, Fig. 11). A precise

relative chronological dating of the pins is difficult, but a position within the Ha A to Ha B1 phases is likely.⁸⁹ Fibulae of the Unter-Radl type can be dated to the Early Urnfield period according to Paul Betzler,⁹⁰ Michaela Lochner⁹¹ and Jiří Říhovský.⁹²

Overall, the differences in the typo-chronological spectrum of phases 2 and 3 are not that distinctive and the finds are typical for the earlier Urnfield period (Ha A) as a whole. For further analyses of the typological spectrum, the division into two phases (1200–1150 and 1150–1100 BC) cannot be maintained and it is more appropriate to combine them (Phase 2/3), broadly dated to Ha A1.

3.3.3. Phase 4: The First Decline 1100–1050/1000 BC

The decline in burial activity visible in the kernel density estimation from around 1100 to 1050 or 1000 BC is also evident in the correspondence analysis. This period is characterized by a small number of types with a wide distribution. Additionally, the error analysis of the interpolation within the correspondence analysis shows a relatively high error rate during this phase (Fig. 8).

It is possible that this decline in burial activity is an artefact caused by the destruction of large parts of the cemetery. It can be speculated that a significant portion of the central area of the cemetery, which was illegally excavated in 1981,⁹³ may have originally dated to this period.

The spindle-headed pin (e.g. 029/14, Fig. 12) of the Gemeinlebarn variant is a type that appears throughout the entire Urnfield period but peaks during the earlier phase, while the small bowl-headed pin (e.g. 177/02, Fig. 12) is present from the Middle Urnfield period onwards.⁹⁴ Likewise, the profiled cups without rim shaping (e.g. 012/11, Fig. 12) fall within this transitional horizon, which can roughly be associated with the transition from the Hallstatt A and Hallstatt B periods.⁹⁵

3.3.4. Phase 5: The Second Peak 1050/1000–950 BC and the Cessation of Burial Activity

The second peak in the activity began around 1050 to 1000 BC and reached its maximum around 950 BC. It is characterized by specific ceramic types, such as cups

⁸⁴ KALICZ-SCHREIBER 2010, type plate 15, Pls. 92, 110, 131.

⁸⁵ WELS-WEYRAUCH 1991, 82–84 and Pls. 27–28.

⁸⁶ KAUS 1971. – GROISS 1976. – HAMPL, KERCHLER, BENKOVSKY-PIVOVAROVÁ 1985. – LOCHNER 1986.

⁸⁷ ŘÍHOVSKÝ 1963. – LOCHNER 1991b, 188–305. – TRNKA, LADENBAUER-OREL 1992.

⁸⁸ LOCHNER 1991b, 260–305.

⁸⁹ ŘÍHOVSKÝ 1979, 145–153. – LOCHNER 1991b, 174–184.

⁹⁰ BETZLER 1974, 16–21.

⁹¹ LOCHNER 1991b, 185–187.

⁹² ŘÍHOVSKÝ 1993, 17–24.

⁹³ GATTRINGER, NEUGEBAUER 1983.

⁹⁴ ŘÍHOVSKÝ 1979, 173–176, 198–207. – NOVOTNÁ 1980, 151, 158. – LOCHNER 1991b, 174–184.

⁹⁵ ŘÍHOVSKÝ 1965, 46–51. – ŘÍHOVSKÝ 1968, 50–53. – EIBNER 1974, 41–53. – LOCHNER 1991b, 298–305.

with a high funnel-shaped neck without rim shaping (e.g. 061/07, Fig. 12), tall cups with more distinct profiles (e.g. 173/07, Fig. 12), complex decorations with groups of lines (e.g. 121/04, Fig. 12), zonal decorations (e.g. 120/01, Fig. 12), profiled cups with conical necks (e.g. 211/06, Fig. 12) and cylinder-necked vessels with rim shaping (e.g. 316/05, Fig. 12). Among the bronze types, there are razors of the Herrnsbaumgarten type (e.g. 169/05, Fig. 12), crescent-shaped razors (e.g. 181/03, Fig. 12) and spindle-headed pins of the Klentnice type (e.g. 173/06, Fig. 12). While the razors roughly date to the Ha B period,⁹⁶ spindle-headed pins of the Klentnice type date to the Middle Urnfield period and later.⁹⁷ This phase of the cemetery can be equated with Ha B1.⁹⁸

Around 950 BC, activity at the cemetery began to decline, eventually ceasing around 850 BC (end boundary: median 891 BC; last: median 859 BC, correspondence analysis interpolation 911 BC). The typological spectrum during this period is characterized by groups of deep grooves in the decorations arranged in zones (e.g. 200/03, Fig. 12), ornaments consisting of broad lines and impressions, cups with S profiles (e.g. 170/01, Fig. 12), knives of the Stillfried type (e.g. 173/03, Fig. 12) and belt hooks of the Unterhaching type (e.g. 120/07, Fig. 12). All these types point to the beginning of the Later Urnfield period, Ha B1.⁹⁹ It can therefore be assumed that the last persons were buried in the cemetery at the end of the early part of the late Urnfield period, around Hallstatt B1.

As is evident from the interpolation, its standard error and the irregularities in the correspondence analysis for this area, there is a noticeable weakness in finer gradations, attributable to several factors. First, relatively few ¹⁴C data points have been collected for this time frame, resulting in a limited dataset. Grave 184 deviates significantly from the expected chronological framework in absolute dating. The razor of the Herrnsbaumgarten type (e.g. 169/05, Fig. 12), the knife of the Hadersdorf type (e.g. 184/06, Fig. 11) and the ceramic assemblage suggest a typical Late Urnfield cultural context.¹⁰⁰ The radiocarbon date, however, with a median of 1143 BC, strongly points to the Early Urnfield period. Whether this discrepancy reflects the incorporation of older burial remains into a later grave, the curation of

cremated remains for some time before burial, the influence of the 'old wood effect' or an unusual early dating of these finds cannot be determined from the available data.

The terminal phase of the cemetery is only represented by a few graves and – similar to the earliest phase – the most recent radiocarbon dates also predominantly come from graves with multiple occupation. As a result, the end of the cemetery's use cannot be fully captured by the analysis. The interpolation of the correspondence analysis indicates a slightly older date than that suggested by the end boundary or 'last event' date. For this reason, future analyses should refrain from separating the last peak phase from the terminal phase of the cemetery based solely on ¹⁴C medians.

3.4. Occupation Sequence

Visually, the cemetery can be divided into different sections, partly determined by the limits of the excavation. Particularly striking is the open area in the centre, which is the result of illegal excavations.¹⁰¹ In the eastern part of the cemetery is a cluster of graves that extends southward, then runs eastward along the southern edge of the cleared area. In addition, all the graves delimited by a ditch are found in the part of the cemetery to the northeast of the open space (Fig. 2).

Geostatistical modelling of both the radiocarbon and the correspondence analysis data confirms this impression. In all interpolated maps, the oldest graves are found in the western zone of the cemetery, showing a slight chronological expansion outward and a more pronounced expansion to the west. However, this expansion is not consistent, leading to some uncertainties and discrepancies between the analyses. In absolute chronological terms, this area spans a period from about 1300 BC to 1100 BC, corresponding to the earliest and older phases of the Urnfield period. Subsequently, there is a gradual expansion of the cemetery towards the southeast, with the most recent dates of both the radiocarbon and correspondence analysis found in the southeastern section (1000–900 BC), where the eastward progression of occupation is much more pronounced.

The circular empty space around the long rectangular pit of Grave 196 raises further questions. The pit was only preserved to a depth of 32 cm and no artefacts or cremated human remains were found, making it uncertain whether it should be classified as a grave or even a cenotaph. If it was indeed a grave, its form would suggest an early date. The open circular space may have originally been a burial mound, now eroded, or marked by a boundary that is no longer visible. Due to the lack of finds, dating this structure

⁹⁶ JOCKENHÖVEL 1971, 203–217.

⁹⁷ ŘÍHOVSKÝ 1979, 176–182.

⁹⁸ ŘÍHOVSKÝ 1965, 46–51. – ŘÍHOVSKÝ 1968, 50–53. – EIBNER 1974, 41–53. – ŘÍHOVSKÝ 1982, 67–81.

⁹⁹ ŘÍHOVSKÝ 1972, 55–58. – KILIAN-DIRLMEIER 1975, 66–71. – LOCHNER 1991b, 170–205. – GRIEBEL, BIEDERER 2022, 100–178.

¹⁰⁰ JOCKENHÖVEL 1971, 208–212. – ŘÍHOVSKÝ 1972, 61–64.

¹⁰¹ GATTRINGER, NEUGEBAUER 1983.

is impossible. However, it can be inferred that the later phase of the cemetery is primarily situated in this area, possibly organized around the older feature.

The northeastern part of the cemetery, which includes the graves enclosed by a ditch, is difficult to date. In the geostatistical interpolation of the correspondence analysis (Fig. 10), this area appears to belong to the later phase of the cemetery, while the radiocarbon data interpolation (Fig. 8) attributes it to the early phase. The interpolated cokriging model shows better resolution in this area, where it appears to belong partially to the older section but predominantly to the transitional phase between the western and eastern sections (Fig. 13). However, the analysis of the standard error in the interpolations shows that this area has relatively high error values. This is partly due to limited data caused by poor preservation in this area and partly because the graves contained uncharacteristic types that are challenging to place in a typo-chronological framework. It is likely that the part of the cemetery with enclosures represents a separate section with distinct burial practices, used from the early to the beginning of the later phase of the cemetery.

In conclusion, the cemetery's occupation pattern does not show a straightforward expansion in a single direction but rather a cluster of small grave group areas. These areas were gradually occupied, with an early phase in the western cemetery and a later phase in the east, possibly centred around an earlier, now eroded monument.

Since the strontium data allowed a distinction between the earlier and later phases of the cemetery based on different subsistence strategies,¹⁰² the cemetery of Inzersdorf might actually represent two (or even more) different burial communities which were either chronologically consecutive or comprised multiple distinct cemeteries, without strict boundaries.

3.5. Dating Burial Customs

3.5.1. Oldest or Conservative Graves?

The old radiocarbon date of Grave 106 of Inzersdorf highlights the importance of the long, rectangular, body-sized graves in the transition from inhumation to cremation¹⁰³ and the subsequent shift from body-sized to urn burials.¹⁰⁴

However, comparing graves of the same type nearby and in the broader region, it becomes evident that this grave form exhibits a high degree of diversity. The cremated remains may be placed in different manners, such as spread

along the grave pit floor, concentrated in the centre, on one side or placed in an urn. In addition, there is significant variation in the presence or absence of grave constructions such as stone settings or post holes. Grave goods are also found in diverse arrangements, including being placed upside down, intentionally broken, or incorporated into the grave structure. Some graves were reused multiple times, while others have been attributed with specific meanings, such as warrior or elite graves.¹⁰⁵ Many of these variations occur simultaneously in the same cemeteries, as they do at Inzersdorf.

Particularly for larger graves and those containing multiple individuals, there has been ongoing discussion about whether depositions occurred simultaneously or over time.¹⁰⁶ The duration of use and frequency of burials varies in collective graves and is especially complex in cremation burials, as the fragmentation of the body through cremation offers a wide range of deposition possibilities.¹⁰⁷

The typological spectrum of the material culture in this grave type at Inzersdorf and other contemporary cemeteries such as Getzersdorf,¹⁰⁸ Mannersdorf,¹⁰⁹ Horn¹¹⁰ or Baierdorf¹¹¹ overlaps in the case of some aspects such as the small and larger cups, footed vessels and conical-neck and funnel-neck vessels, whereas other features are unique. More importantly, there is little continuity within the typological spectrum from this grave type to the others. This might be due to the unique temporal placement of the graves. However, objects found in graves, be they grave goods, offerings, sacrifices or similar, need to be considered actors within the death and burial rituals, loaded with meaning and placed in a highly deliberate way.¹¹²

Comparing radiocarbon dates of the long rectangular graves with those of the urn graves, it is immediately noticeable that both cover a relatively long time span. For a more detailed analysis, kernel density estimations were created for both grave types (Fig. 13). Long rectangular graves peak at around 1300 BC, before their frequency slowly tapers off, until they finally fade out in around 1000 BC (Fig. 13, green curve). The very latest burials of this type already date to the later Early Urnfield period. The double burial Grave 006 even dates to the beginning of the Late Urnfield period

¹⁰² FRITZL et al. 2024.

¹⁰³ SØRENSEN, REBAY-SALISBURY 2023, 149–173.

¹⁰⁴ LOCHNER 2013. – FALKENSTEIN 2017.

¹⁰⁵ KAUS 1975. – LOCHNER 1986. – KAUS 2006. – KRAPE, WITTWER-BACKOFEN 2011.

¹⁰⁶ HESS 2013. – FRITZL 2017, 88–90.

¹⁰⁷ REBAY-SALISBURY, SØRENSEN, HUGHES 2010, 64–71.

¹⁰⁸ KAUS 1971. – GROISS 1976.

¹⁰⁹ POMBERGER 2009, 26–55.

¹¹⁰ LOCHNER 1991a.

¹¹¹ LOCHNER 1986.

¹¹² HINZ 2009, 33. – GRAMSCH 2010, 129–130. – HOFMANN 2013, 272. – FRITZL et al. 2019.

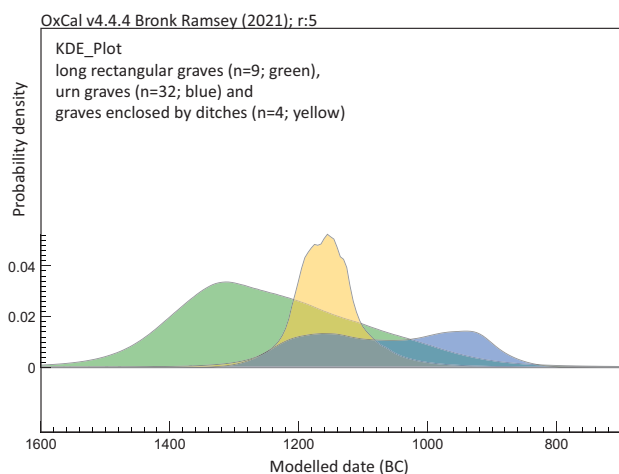


Fig. 13. KDE plot. – Green: Long rectangular graves; yellow: enclosed graves; blue/grey: urn graves.

(1107–917 BC, 2σ). The first urn graves (Fig. 13 blue and grey curve), by contrast, appear in around 1300 BC with a first peak around 1200 BC. It should be borne in mind that statistics do not exclude the possibility of a stricter chronological succession, especially as significant confidence intervals make it impossible to pinpoint certain events exactly. However, due to the number of ^{14}C -dated graves (long rectangular: $n = 8$, urn: $n = 32$) this appears unlikely.

While long rectangular graves occur in the early phase of the cemetery and some of them represent the very oldest graves, this grave type is not exclusively used during this time; it is in use for much longer than previously assumed and its use extends quite far into the early phase of the Urnfield period. Datable typo-chronological features place them in BA D/Ha A1 in relative terms. It could thus be argued that the boundary between BA D and Ha A1 is not strict at all but allows for contemporaneous ritual developments. The use of the long rectangular graves as a conservative grave style by part of the burial community may also be reflected by the use of antiquated types of material culture for pyre and grave goods. Previous studies have often demonstrated that a transition from one burial ritual to another is not abrupt and consistent but rather occurs gradually, slowly and in waves.¹¹³

3.5.2. Graves Surrounded by Circular Ditches

Graves encircled by ditches are often interpreted as burial mounds or remnants of poorly preserved mounds, which are predominantly associated with the Middle Bronze

Age.¹¹⁴ However, no additional evidence has been found at Inzersdorf to support this interpretation. Instead, graves surrounded by ditches have been observed in various burial contexts across different cemeteries, with a range of appearances, also without further reference to burial mounds. Norbert Wiesner¹¹⁵ identifies a broad distribution of this grave type across Europe with two main centres. The southern part of the eastern centre distributed in southern Germany/Bavaria extends into Lower Austria. Further, two groups of grave enclosures can be distinguished, those with an entrance and those without. Their shape ranges from round to oval to rectangular, with round shapes thought to be predominant during the Urnfield period.¹¹⁶

All eleven graves surrounded by ditches at Inzersdorf are located in the northeastern area of the cemetery interspersed with simple urn graves, thus constituting a distinct group within the excavated area. In addition to the eleven circular ditches, one square enclosure was observed. Since the typological spectrum of the burial is not indicative and the structure is spatially set apart in the southern area of the cemetery, where a La Tène cemetery was also found,¹¹⁷ radiocarbon dating was indicated. The radiocarbon date, ranging from 791 to 544 BC, confirmed an Early Iron Age date. Due to the ‘Hallstatt plateau’ in the calibration curve, a more precise dating is not possible. The grave may date to the transition from the Late Bronze Age to the Iron Age, as similar features are known from Late Bronze Age Franzhausen-Kokoron.¹¹⁸

The northeastern part of the cemetery is especially poorly preserved and contains many significantly disturbed and eroded enclosed graves. Most of the graves lack clear typological references, and the empirical Bayesian kriging of the correspondence analysis (Fig. 6) shows a considerable error in this area. However, with the exception of Grave 182 (the rectangularly enclosed grave), a dating to the Early Urnfield period is highly probable. Graves with circular ditches do not appear to belong to the very early graves of the cemetery; their peak occurs between 1200 and 1100 BC, coinciding with the earlier peak of the urn graves.

The poor agreement of the radiocarbon and typo-chronological dating must be explained, even if the data quality is comparatively poor. Out of the four ^{14}C -dated graves (graves 061, 065, 075 and 143), graves 065 and 143

¹¹⁴ LOCHNER 2013.

¹¹⁵ WIESNER 2009, 270–288.

¹¹⁶ WIESNER 2009, 271.

¹¹⁷ NEUGEBAUER 1996.

¹¹⁸ LOCHNER, HELLERSCHMID 2016, e.g. features 700–701, 711–712, 721, 728, 575, 576.

¹¹³ CAVAZUTTI et al. 2022. – SØRENSEN, REBAY-SALISBURY 2023, 23–28.

show no typologically chronologically classifiable features at all. The other two graves contain exceptional finds such as the ceramic vessels with a very high neck or rim shaping in Grave 061 and the knife with curved handle in Grave 075 that provide no chronological baseline. The other artefacts from these two graves, however, such as the turban-rimmed bowls and the conical-necked vessel from Grave 061, as well as the bowl-headed pin from Grave 075, clearly indicate the beginning of, if not established, later Urnfield period.¹¹⁹ Consequently, both graves are found roughly in the middle of the correspondence analysis plot (Fig. 8). The quite extensive variability in the typological spectrum and the burial custom complicate precise chronological investigations in this area.

3.5.3. Graves Containing More Grave Goods than Pyre Goods

Small urn graves with fire-affected objects predominate in the Early Urnfield period, whereas during the Middle Urnfield period, there is a general trend toward the inclusion of a larger number of unburnt grave goods, in particular vessels. This shift, however, is not absolute; rather, it is part of a general increase in the deposition of material culture in graves, which coincides with larger grave sizes.¹²⁰

Relatively few graves with clearly positioned grave goods are found at Inzersdorf. This may be partly due to preservation, as many ceramic finds were heavily fragmented and not recovered in identifiable positions. Although graves with clearly positioned grave goods tend to be more often identified as adult graves, frequently those of men, this is not exclusively the case. Additionally, uniform urn graves include individuals of all age and gender groups. Some of these can indeed be described as richly furnished, with numerous cremated offerings, dress accessories and ceramic items. This suggests that this mode of burial was, to some extent, independent of social status and instead related to chronological developments.

Radiocarbon dates of burials with few grave goods ($n = 14$) and burials containing more grave than pyre goods ($n = 6$) in a KDE plot (Fig. 14) reveal that graves with few positioned grave goods appear in both peak phases of the cemetery. The peak for these graves is significantly higher in the earlier phase, reaching its maximum at around 1200 to 1100 BC, compared to the later peak of burials, which is around 950 BC. By contrast, graves with more grave than pyre goods show only a single peak, around 1000 BC, which

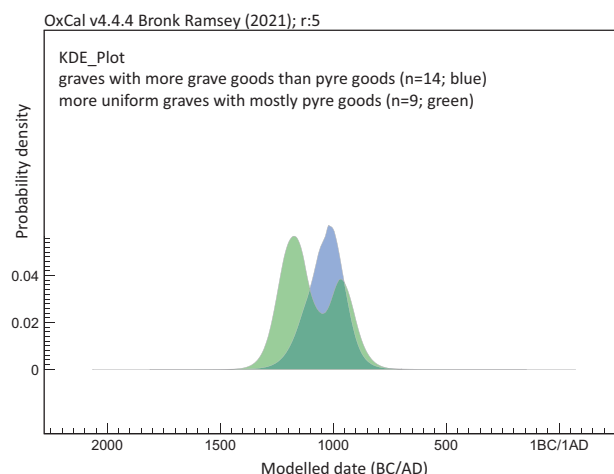


Fig. 14. KDE plot. – Green: Urn burials with mostly pyre goods; blue: urn burials with more grave than pyre goods.

largely overlaps with the later phase of the cemetery. Although graves with clearly positioned grave goods appear as early as 1200 BC, they are most frequent at around 1000 BC. In the later phase they do not represent the only burial type but coexist, albeit to a lesser extent, with uniform, small urn graves. From a typo-chronological perspective, this grave type shows no notable differences compared to the homogeneous uniform urn graves; the sequence progresses consistently in chronological order. This once again highlights that multiple burial modes coexisted simultaneously, indicating a certain range of variation within burial rituals that was not limited to specific gender, age or status groups.

3.5.4. Graves with Multiple Occupations

Twelve of the 21 graves with remains of more than one individual at Inzersdorf ob der Traisen were radiocarbon dated, for seven of these taking two or three samples of different individuals per grave (Tab. 3). Graves in which separate burial deposits were identified during excavation were prioritised for sampling, as they were most likely to exhibit a time gap and reveal collective burials or ancestor curation.¹²¹

From the analysis of all graves with multiple radiocarbon dates, a clear division into two distinct groups is evident: the calibrated radiocarbon dates of three graves (graves 106, 004 and 029) overlap, although in some cases the overlap is minimal. For instance, in Grave 004 there is only a two-year overlap within the 1σ interval (004/I: 1220–1125 BC; 004/II: 1369–1218 BC). This suggests the individuals were contemporaneous. Four graves (graves 006, 017, 032 and 170), by contrast, show no overlap at all, neither within the 1σ nor

¹¹⁹ ŘÍHOVSKÝ 1965, 46–51. – EIBNER 1974, 41–53. – ŘÍHOVSKÝ 1979, 198–207. – NOVOTNÁ 1980, 151.

¹²⁰ LOCHNER 2013.

¹²¹ FRITZL 2017, 88–90.

Sample ID	Sex	Age at death	Location in the grave	Lab code	¹⁴ C Age BP ± σ	Age cal BC (2 σ , 95.4 % probability)	Age cal BC (1 σ , 68.3 % probability)	Difference/ overlap (2 σ , 95.4 % probability)	Difference/ overlap (σ , 68.3 % probability)	Median calibrated calendar age
INZ004/I	probably female	> 20 yrs	In the urn	RICH-31800	2962 ± 26	1265–1055 BC	1220–1125 BC	134 overlap	2 overlap	1175 BC
INZ004/II	undet.	1.3–1.8 yrs	West of the urn	RICH-32443	3016 ± 25	1386–1131 BC	1369–1218 BC			1262 BC
INZ006/I	female?	> 20 yrs	On the grave floor	RICH-31807	2839 ± 25	1107–917 BC	1044–932 BC	129 difference	241 difference	993 BC
INZ006/II	probably male	35–50 yrs	On the grave floor	RICH-34138	3066 ± 27	1414–1236 BC	1391–1285 BC			1336 BC
INZ017/I	female??	35–45 yrs	In the urn	RICH-32430	2635 ± 23	827–784 BC	811–794 BC	386 difference	418 difference	804 BC
INZ017/II	undet.	3–9 mths	East of the urn	RICH-34140	3035 ± 27	1397–1213 BC	1379–1229 BC			1292 BC
INZ029/I	male??	20–40 yrs	In an urn	RICH-34139	2835 ± 36	1111–906 BC	1045–928 BC	103 overlap	26 overlap	991 BC
INZ029/II	undet.	0–19 yrs	In an urn	RICH-32416	2900 ± 25	1201–1008 BC	1122–1019 BC			1084 BC
INZ032/I	probably male	30–50 yrs	In the urn	RICH-32447	2753 ± 24	977–826 BC	920–836 BC	40 difference	132 difference	881 BC
INZ032/II	female	> 20 yrs	Above the urn	RICH-32449	2918 ± 25	1212–1017 BC	1192–1052 BC			1111 BC
INZ106/I	female??	> 20 yrs	Southern area of cremains	RICH-31804	3049 ± 30	1404–1222 BC	1386–1263 BC	118 overlap	75 overlap	1312 BC
INZ106/II	undet.	1–6 yrs	Northern area of cremains	RICH-32450	3114 ± 30	1446–1286 BC	1427–1311 BC	1184 difference	1264 difference	1386 BC
INZ106/III	undet.	9–13 yrs	unclear	RICH-32434.1.1	2014 ± 36	102 BC–AD 117	47 BC–AD 59	1120 difference	1216 difference	2 BC
INZ170/I	male	35–44 yrs	In the urn	RICH-32414.1.1	2993 ± 36	1386–1112 BC	1283–1128 BC	109 difference	150 difference	1228 BC
INZ170/II	undet.	8–11 yrs	Above the urn	RICH-32422.1.1	2776 ± 26	1003–836 BC	978–847 BC			920 BC

Tab. 3. Calibrated ¹⁴C dates of multiple graves. The three-digit number after INZ indicates the grave number; I, II and III refer to the individual buried in graves with multiple occupation.

within the 2σ intervals. The time gaps between individuals in these graves range from 132 to 418 years within the one σ interval and from 40 to 386 years within the two σ interval (Tab. 3).

3.5.4.1. Connected Through Time

Two out of three graves with two burials and overlapping radiocarbon date ranges, including the previously discussed Grave 106 (Fig. 10), involve a woman and a small child, the most common combination in double burials in the entire cemetery.¹²² Grave 004 included one individual (004/I), most likely a woman, placed in an urn, whilst a young child (004/II) was found partly within and partly next to the urn. This grave is especially notable due to the abundant jewellery, especially the sheet-metal objects found inside the urn. Such items are barely known from this region and indicate a clear connection to the southeastern Čaka group,¹²³ making this grave particularly relevant for understanding foreign influences and the development of the Urnfield period. Using R_Combine in OxCal, the radiocarbon date for Grave 004 (2990 ± 19 BP) is calibrated to two main ranges: 1284–1155 calBC (85.7 %) and 1149–1126 calBC (9.7 %), with a peak probability around 1155 calBC. The X^2 test ($T = 2.2 < 3.8$) confirms the statistical consistency of the combined measurements. This suggests the deaths of the two individuals might have been close in time. If a time difference existed, the young child placed next to the urn would be the earlier individual, while the woman in the urn would date later. The strontium isotope ratios match exactly, indicating that these individuals consumed a very similar diet during their lifetime. This argues against the possibility that the cremated remains of the child were stored and only buried later.¹²⁴ Following this argument, the dating of this grave could be narrowed down to between 1265 and 1131 BC, 2σ .

Grave 029 is the only double burial in which both individuals were placed in separate urns. It also contains the only individual (029/II) identified as non-local by strontium isotope analysis.¹²⁵ While the non-local individual, a 3–18-year old subadult, is potentially the older of the two burials (1201–1008 BC, 2σ), the second individual, a 20–40-year-old male (029/I), dates to 1111–906 BC, 2σ . Though the overlap period is relatively brief at the 1σ level, it is still significant enough that the two individuals may have lived at the same time. Further, again the X^2 test ($T = 2.2 < 3.8$)

indicates statistical consistency of the combined data from Grave 029 (1126–983 calBC; 94.3 %). Therefore, though it is tempting to speculate that the remains of the chronologically older, non-local individual may have been preserved for a longer period, or perhaps even transported over a considerable geographical distance to be buried at Inzersdorf, the radiocarbon data does not provide further proof for this hypothesis.

3.5.4.2. Separated by Time

The temporal distance between individuals within the 2σ interval ranges from 132 to 418 years, and within the 1σ interval, from 40 to 386 years (Tab. 3). This notable difference of up to 13 generations – assuming an average generation of 30 years – allows for various interpretations. Three out of four cases involve men buried with a woman or a child (infans II). In addition, three out of four graves with non-overlapping dates include a spatial separation between the buried individuals.

Grave 017 (Fig. 15) shows a significant temporal gap of 386 years between the buried individuals. It includes a woman buried in an urn, with an infant placed next to it. Surprisingly, the cremated remains of the child date much earlier (017/II, 1397–1213 BC, 2σ , Early Urnfield period) than the woman (017/I, 827–784 BC, 2σ , Latest Urnfield period or beginning of the Early Iron Age). One might initially assume a disturbed child's grave, with the remains accidentally/intentionally incorporated into the fill of the woman's grave. However, the typo-chronological spectrum of this richly furnished grave clearly points to the Early Urnfield period. The urn is a cylindrical-necked vessel with pointed knobs, and the finds include cups with sharp profiles, massive ribbed bracelets and ball-headed pins.

The grave is clearly centred around the remains of the cremated woman, and yet the radiocarbon date of the cremated remains does not align with the assemblage of material culture. Given the high number of items found in this grave, it seems unlikely that these artefacts are the result of a redeposition, and no finds specifically indicate the absolute chronological age of the woman.

A possible explanation is that the cremated remains of the child and its related offerings were curated for an extended period of time and later buried together with the first individual, perhaps in connection with some kind of ancestor worship. At present, there are no directly comparable contexts, although taking multiple radiocarbon dates from one grave has revealed time differences.¹²⁶ Although it

¹²² FRITZL 2017, 103.

¹²³ TOČÍK, PAULÍK 1960. – HELGERT 1995. – KALICZ-SCHREIBER 2010, type plate 14, Pls. 54, 80, 84, 106, 155.

¹²⁴ FRITZL et al. 2024.

¹²⁵ FRITZL et al. 2024.

¹²⁶ SABAUX et al. 2021. – SABAUX et al. 2024.

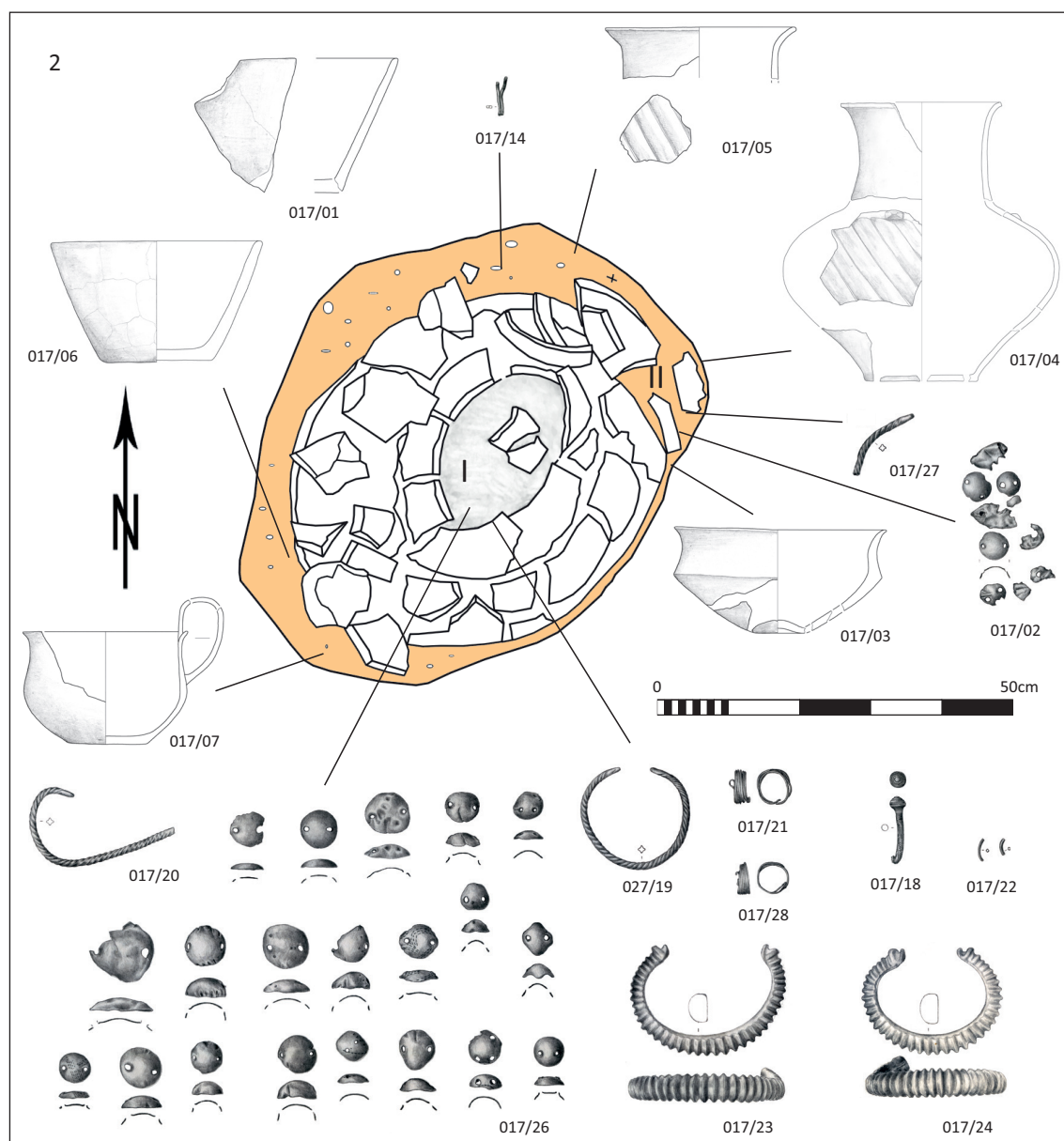


Fig. 15. Grave 017 and the finds for which a precise location could be identified.

has been suggested that cremated remains or bones of the deceased may have been kept for a longer period of time before they were buried,¹²⁷ whether this also applies to grave or pyre goods has not been discussed.¹²⁸

It is also possible that the particular bone sampled for radiocarbon dating was introduced by a disturbance. However, the urn was covered by a stone, and care was taken to ensure that the sampled bone elements were as clearly

attributable as possible to the respective burials. It would be more likely that the much less represented, earlier individual was introduced by disturbance, but as the grave goods fit this individual much better, this also seems unlikely. Furthermore, both individuals are relatively well represented, with approximately 507 grams of cremated remains for the woman and 41.6 grams for the child, which is a relatively large amount for an infant aged three to nine months. Therefore, contamination is unlikely in either case.

The long, rectangular Grave 006 contained the burial of a man (006/II) and a woman (006/I) whose cremated remains were inseparably mixed (Fig. 16). Nevertheless, the two

¹²⁷ WAHL 1994. – MCKINLEY 2013.

¹²⁸ FRIEMAN 2012. – JENNINGS 2014, 11–18.

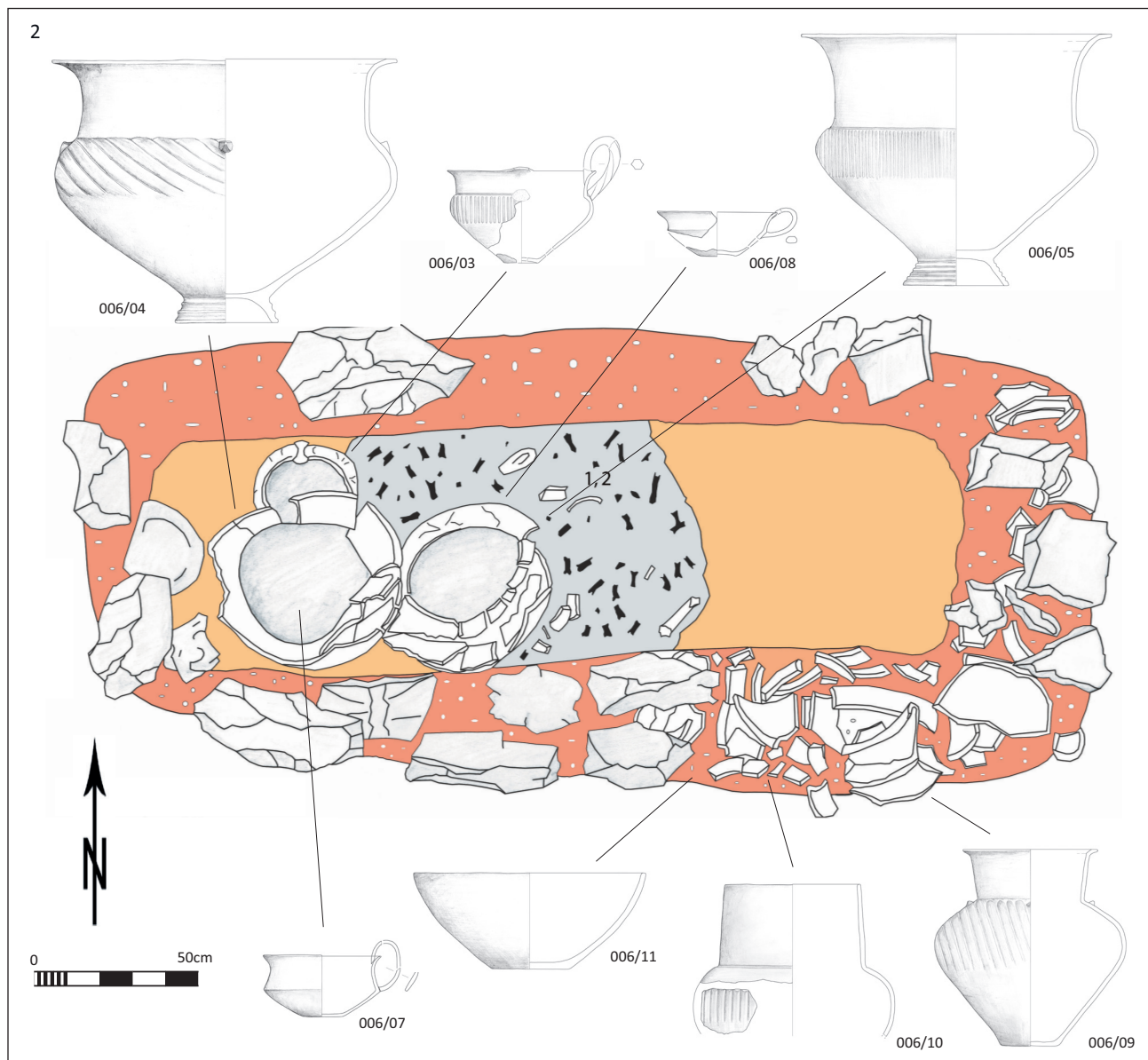


Fig. 16. Grave 006 and the finds for which a precise location could be identified.

measured ^{14}C values show a clear difference of 241 in the 1σ and 129 years in the 2σ interval. This grave type represents a relatively old grave form within the cemetery, and the grave goods appear to align with this classification. The grave's archaeological appearance aligns with the earlier radiocarbon date (that of the male individual, 1414–1236 BC, 2σ), while the woman's ^{14}C date of 1107–917 BC, 2σ appears much too recent. The woman's remains, represented by approximately 963 g, indicate a primary interment rather than a coincidental addition. The man, by contrast, is only represented by about 27 g. It is possible that the man's old grave was disturbed when the grave was prepared for the woman. However, no such disturbance is evident in the archaeological record.

Another possibility is that this structure was a collective grave used on multiple occasions, as appears to be the case with similar graves,¹²⁹ but since only the remains of two individuals were found, frequent reuse seems unlikely, even though cremated remains can often be difficult to separate by individual.¹³⁰ The presence of a number of (possibly intentionally?) broken vessels within the stone packings, however, supports this idea. Additionally, a built stone structure described provisionally as a 'step' was found within the

¹²⁹ KRAPF 2010. – HESS 2013, 200–230.

¹³⁰ WAHL 1982. – GROSSKOPF 2004, 126–129.

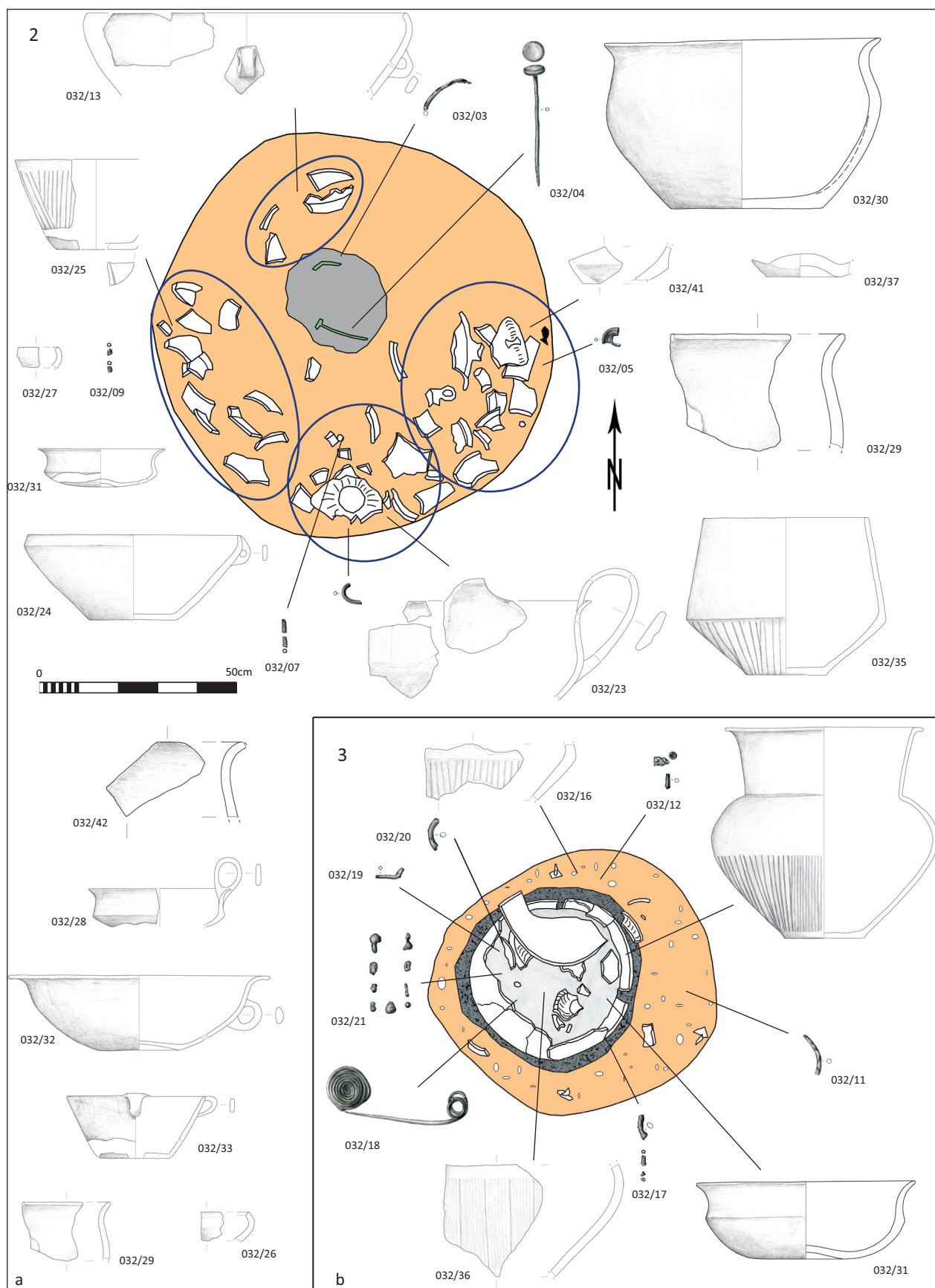


Fig. 17. Grave 032 and the finds for which a precise location could be identified. – a. Planum 2 containing the burial of Individual 032/II. – b. Planum 3 containing the burial of Individual 032/I.

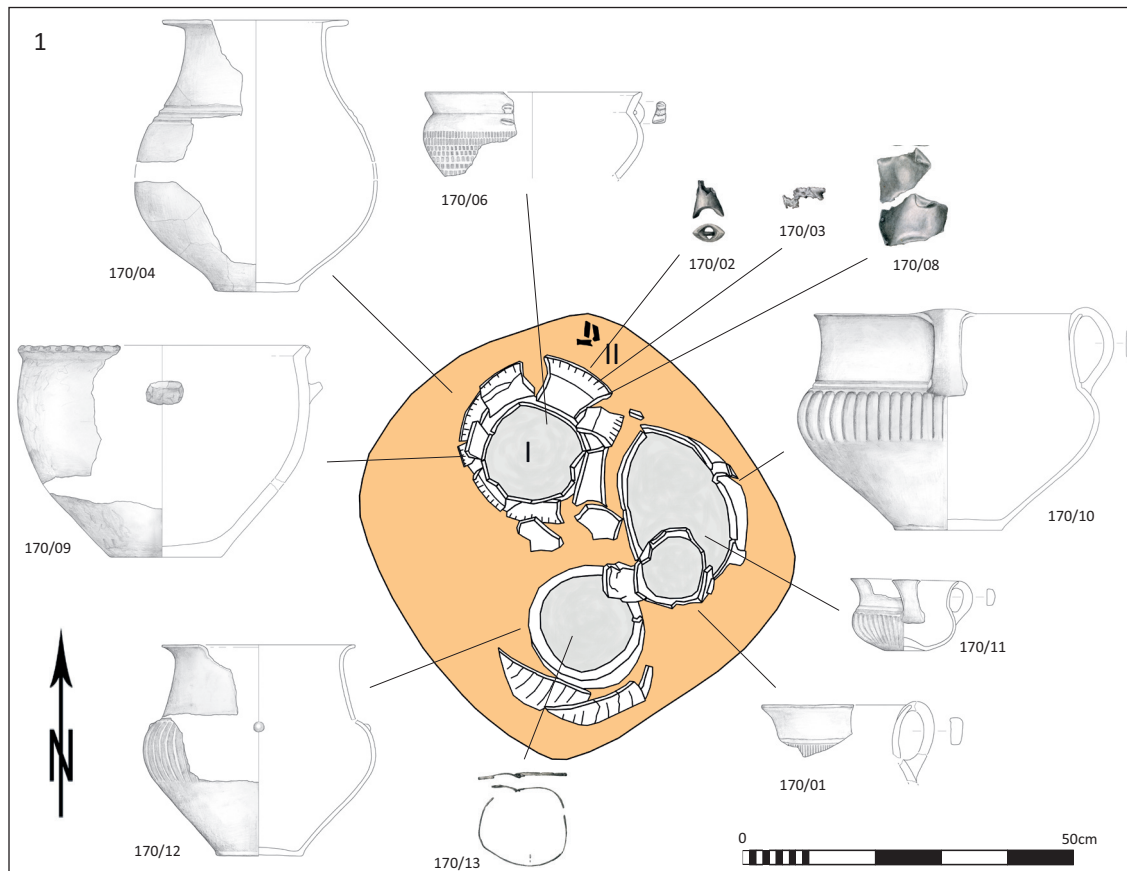


Fig. 18. Grave 170 and the finds for which a precise location could be identified.

stone packings. This may suggest that the grave could have been reopened for further ritual purposes. However, there are no recorded distortions to suggest any post-burial practices such as grave robbing or later additions.

Grave 032 contained the remains of at least three individuals. A 31–50-year-old man (032/I) was found in the urn (Fig. 17). Mixed among the burnt remains was the *pars petrosa* of a foetus (032/III). This single bone may be considered an accidental addition. By contrast, it could be suggested that this visually striking bone was intentionally added, possibly as a symbolic *pars pro toto* deposition. A similar context with a foetal *pars petrosa* mixed with a male individual was found in Grave 040 at Inzersdorf, supporting the notion of a deliberate practice.¹³¹

The second individual buried in this grave (032/II), a 20+-year-old woman, was found scattered in a pile above the urn and surrounded by numerous ceramic fragments. While the individual in the urn has a relatively recent radiocarbon date (977–826 BC, 2σ), the date of the woman's remains on

top of the urn is significantly older (1212–1017 BC, 2σ). Most of the ceramic grave goods associated with the woman can be clearly dated to the Early Urnfield period.¹³² The few diagnostic grave goods found with the male burial, such as the fibula of Unter-Radl type, also point to the earlier Urnfield phase.¹³³ Furthermore, the time interval between the dates of the two individuals is only 40 years (2σ), which is roughly equivalent to one generation. It is possible to interpret the findings in terms of a disturbed grave, with the remains shifted into the fill of a new grave, but it is also possible that the woman's remains were kept for a while before being buried together with the remains of the man.

Grave 170 includes the double burial of a 35–44 year-old male individual (170/I) in the northern part of the grave (Fig. 18), with a radiocarbon date of 1386–1112 BC, 2σ, corresponding to the earlier phase of the cemetery. The second individual (170/II), a child aged approximately 8 to 11 years, was found scattered in a small pile above the urn.

¹³¹ FRITZL 2017, 99, 396.

¹³² ŘÍHOVSKÝ 1963. – LOCHNER 1991b, 170–305.

¹³³ BETZLER 1974, 16–21. – ŘÍHOVSKÝ 1993, 17–24.

The radiocarbon date of these cremated remains is 1003–836 BC, 2σ . This grave is more straightforwardly interpretable as that of a man, with a second individual added later. However, the grave's layout and composition corresponds to the later burial type: in addition to the urn, there are unburned ceramic grave goods, and the ceramic types point to the mid to late Urnfield period.¹³⁴ The typo-chronological age of this assemblage aligns more closely with the second, later individual. Furthermore, some items found in the grave are unique to the entire cemetery, such as a damaged bronze tool, a very delicate bracelet made of sheet metal, and a cup fragment with a decoration that is unparalleled in this cemetery, this region or even the time period. While it is possible that an older grave was disturbed, it is plausible that in this case the remains of the man were kept to be buried together with the child at a significantly later time, considering the gap of 101 years, 2σ .

3.5.4.3. Single Data Points from Graves with Multiple Occupation

Six radiocarbon dates come from graves with multiple individuals, of which only one was tested (Tab. 4). Not all graves contained suitable material for dating, and the primary goal in the sampling strategy was to anchor the typological dating in absolute terms. Four of these individuals (027/II, 202/II, 248/I and 258/I) align reasonably well with the general typological expectations; two (210/II and 003/I) stand out as exceptions.

The burial type and characteristic grave goods of Grave 210, such as pottery with groups of deep grooves in the decorations arranged in zones and ornaments consisting of broad lines and knobs, correspond to the Middle and Late Urnfield period.¹³⁵ The radiocarbon date (1220–1017 BC, 2σ), however, hints at the Early Urnfield period. It remains possible that Grave 210 is a very early variant of this burial type, but the undated individual in the grave may be later in absolute chronological terms.

The radiocarbon date of the first individual from Grave 003 (1002–835 BC, 2σ) clearly points to the Late Urnfield period. The grave goods, however, include a knife of the Riegsee type, which is normally assigned to the later Bronze Age or earliest Urnfield period (BA D).¹³⁶ The knife shows clear signs of intentional destruction, an unusual practice at Inzersdorf. It is possible that this individual was buried with an heirloom item, yet it cannot be ruled out that

the other individual in this grave might yield a considerably earlier absolute date. This hypothesis is supported by the fact that only one other single grave, Grave 184, shows discrepancies between the relative, typo-chronological dating and the absolute radiocarbon dates.

The data derived from multiple burials remains complex and difficult to interpret. Although it cannot be clearly outlined, it is evident that there is an underlying funerary practice or activity associated with the deposition of the remains of more than one person in the grave. In particular, more than half of the multiple occupation graves that yielded multiple radiocarbon samples have no overlap in dates, and these contexts often show evidence of deliberate depositional activity. In three out of four cases, the combination is a man and child rather than a woman and child, which is generally much more common. This suggests that specific co-burial patterns are present, although their exact nature and significance remain elusive.

4. Conclusion

The chronology of Inzersdorf, established by combining radiocarbon dates with correspondence and statistical analyses, provides a nuanced understanding of its occupation phases and delineates temporal shifts within the Urnfield period in the Traisen Valley region. The typo-chronological analysis is mostly consistent with radiocarbon dating, although there are exceptions that indicate the curation of human remains and grave goods.

The analysis reveals a potentially earlier beginning of the cemetery than previously thought, with radiocarbon dating suggesting its use may extend back to the Middle Bronze Age around 1383–1280 BC. A comparison with nearby contemporary cemeteries highlights the complex temporal framework and regional variations in burial practices, challenging the assumption of a linear progression of developing mortuary rites. Funerary activities begin by a median radiocarbon date of 1325 BC, referring to the start boundary, retaining links to the Middle Bronze Age funerary practices, and progress through phases defined by typological markers. The analysis identifies two peak phases of cemetery use (1200–1100 BC and 1020/1000–950 BC), in which burial practices and artefact assemblages increasingly suggest evolving cultural expressions associated with the Ha A and Ha B phases. After these peaks, burial activity decreases around 950 BC, with a final decline around 850 BC, indicating the cemetery falling into disuse towards the Hallstatt B period.

Grave 106, notable for its unique construction and the presence of multiple individuals, contained two of the cemetery's oldest individuals in long, oval scatterings at the base

¹³⁴ WIESNER 2009, 115–116. – LOCHNER 2013.

¹³⁵ LOCHNER 2013.

¹³⁶ ŘÍHOVSKÝ 1972, 13–16. – OVERBECK 2018, 292.

Sample ID	Sex	Age at death	Location in the grave	Lab code	¹⁴ C Age BP $\pm \sigma$	Age cal BC (2 σ , 95.4 % probability)	Age cal BC (1 σ , 68.3 % probability)	Median calibrated calendar age
INZ003/I	undet.	> 20 yrs	Both in the urn	RICH-32425.1.1	2775 $\pm$ 29	1002–835 BC	979–843 BC	919 BC
INZ027/II	undet.	> 20 yrs	Both in the urn	RICH-32440	2917 $\pm$ 26	1211–1016 BC	1191–1051 BC	1110 BC
INZ202/I	ambig.	30–50 yrs	Both in the urn	RICH-32451	2741 $\pm$ 23	928–821 BC	906–834 BC	870 BC
INZ210/II	male	30–50 yrs	Individual II within the urn; Individual I above the urn	RICH-32445.1.1	2929 $\pm$ 28	1220–1017 BC	1200–1056 BC	1131 BC
INZ248/I	female??	30–50 yrs	Both on the grave floor	RICH-32437.1.1	3088 $\pm$ 30	1422–1276 BC	1411–1302 BC	1345 BC
INZ258/I	female	> 40 yrs	Both in the urn	RICH-32427	2907 $\pm$ 24	1202–1012 BC	1155–1020 BC	1093 BC

Tab. 4. Calibrated ¹⁴C dates of single individuals from multiple graves. The three-digit number after INZ indicates the grave number; I, II and III refer to the individual buried in graves with multiple occupation.

of a square grave pit, with a third individual dating to the Roman Imperial period likely added during a later reuse of the grave. Such ‘founder’s graves’ are assumed to hold symbolic significance still recognised after an extended period of time.¹³⁷ The use of long rectangular graves at Inzersdorf peaks around 1300 BC and gradually declines around 1000 BC, overlapping with the introduction of urn graves around 1200 BC. The burial practices at Inzersdorf therefore probably reflect a slow, overlapping transition rather than a strict chronological sequence. Graves surrounded by ditches highlight the challenges of relying solely on either radiocarbon or typological data for dating. The radiocarbon results point to an Early Urnfield period date for most of these graves, with a peak around 1200–1100 BC. Few artefacts provide typo-chronological anchors, and unique, potentially foreign items complicate classifications. Overall, an early to medium placement of this grave type must be assumed.

The change in burial practices over time is also evident in the graves containing numerous grave goods, which are clearly displayed in the grave pit. Kernel density estimation plots of radiocarbon dates show that the frequency of such graves increases markedly around 1000 BC, although they coexist with more modest urn burials, underlining the simultaneous existence of different burial modes. The distinct sections of the cemetery revealed by empirical Bayesian kriging show a complex pattern of occupation rather than a linear progression through time. The results indicate an earlier phase concentrated in the western zone and a later phase extending to the southeast, with potential implications for understanding community dynamics in the region.

The detailed account of the multiple burials at Inzersdorf provides further insights into mortuary rituals. Radiocarbon dating has revealed several cases (e.g. graves 017, 032 and 170) where the dates of individuals buried together do not overlap in time. Chronological gaps of over 300 years indicate that certain individuals may have been added to an existing grave, or may have been curated long after the initial burial or death of an individual. In some instances this even extends to the curation of pyre and grave goods that appear to be ancient. The positioning of individuals in the graves varies, with some placed inside urns, others next to or above urns, and still others directly at the bottom of the grave pits. This practice may indicate ancestor worship or the deliberate curation of remains for long-term ritual purposes. Graves such as 006 and 106, where cremains were mixed or graves showed structural evidence of repeated use such as ‘steps’, may indicate pre/inter/post mortem rituals.

The evidence from Inzersdorf’s varied burial styles suggests a complex, multi-phase use of the cemetery, characterized by gradual shifts rather than abrupt changes in burial customs. The variation in grave construction, the arrangement of grave goods and the use of specific types underlines this complexity, suggesting that grave goods and burial practices were linked to the sometimes more conservative and sometimes more progressive customs of particular groups. Recent studies echo this, emphasizing gradual, wave-like transitions in burial practices.¹³⁸ Funerary choices may reflect adherence to ancestral practices, underscoring that burial styles such as the long rectangular graves were not only products of a temporal sequence but also of cultural continuity and identity. The recurrent discrepancy

¹³⁷ PRIMAS 2008, 76–77. – KRAPF 2010.

¹³⁸ MÜLLER-SCHESSEL 2013, 174–199. – FALKENSTEIN 2017. – SØRENSEN, REBAY-SALISBURY 2023, 86–112.

between radiocarbon dates and typological expectations may reflect a deliberate blending of the past and present, a concept common in various ancestor-focused societies where material remnants of the past are used to legitimize current social practices and continuity. Taken together, the chronological data reveal nuanced burial practices at the cemetery of Inzersdorf, where the cemetery functioned not only as a place of final repose but also as an active, temporally layered site of cultural expression, memory and identity.

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Appendix 1

The starting and final matrix of the correspondence analysis and eigenvalues of the graves and types can be found at: doi: 10.1553/archaeologia109s177-A1.

Appendix 2

Supplementary figures and model diagnostics can be found at: doi: 10.1553/archaeologia109s177-A2.

Data Availability

A catalogue of grave contexts, finds and bio-archaeological profiles of the buried individuals is available at https://epub.oeaw.ac.at/Graeberfeld_Inzersdorf.

Author Contributions

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References

- BÁNFFY et al. 2018
- E. BÁNFFY, A. BAYLISS, A. DENAIRE, B. GAYDARSKA, D. HOFMANN, P. LEFRANC, J. JAKUCS, M. MARIC, K. OROSS, N. TASIĆ, A. WHITTLE, Seeking the Holy Grail: robust chronologies from archaeology and radiocarbon dating combined, *Documenta Praehistorica* 45, 2018, 120–137. doi: 10.4312/dp.45.10.
- BETZLER 1974
- P. BETZLER, Die Fibeln in Süddeutschland, Österreich und der Schweiz I: Urnenfelderzeitliche Typen. *Prähistorische Bronzefunde* 14/3, Munich 1974.
- BLES 2012
- C. BLES with contributions by D. KERN, M. KRENN, A. PREINFALK, F. PREINFALK, R. RISY, E. STEIGBERGER, K. WILTSCHKE-SCHROTTA, Zeugen der Vergangenheit: Archäologie im Unteren Traisental – von den Steinzeiten bis zur Gründung des Stiftes Herzogenburg im Mittelalter. *Fundberichte aus Österreich, Materialhefte A18*, Vienna 2012.
- BØLVIKEN et al. 1982
- E. BØLVIKEN, E. HELSKOG, K. HELSKOG, I. M. HOLM-OLSEN, L. SOLHEIM, R. BERTELSEN, Correspondence analysis: an alternative to principal components, *World Archaeology* 14, 1982, 41–60. doi: 10.1080/00438243.1982.9979848.
- BRADLEY, SMITH 2007
- R. BRADLEY, A. SMITH, Questions of context: a Greek cup from the River Thames. In: C. GOSDEN, H. HAMEROW, P. DE JERSEY, G. LOCK (Eds.), *Communities and Connections. Essays in Honour of Barry Cunliffe*. Oxford 2007, 30–42.
- BRONK RAMSEY 2009
- C. BRONK RAMSEY, Bayesian analysis of radiocarbon dates, *Radiocarbon* 51/1, 2009, 337–360. doi: 10.1017/S0033822200033865.
- BRONK RAMSEY 2017
- C. BRONK RAMSEY, Methods for summarizing radiocarbon datasets, *Radiocarbon* 59/6, 2017, 1809–1833. doi: 10.1017/RDC.2017.108.
- BUCK, CAVANAGH, LITTON 1996
- C. E. BUCK, W. G. CAVANAGH, C. LITTON, Bayesian Approach to Interpreting Archaeological Data. *Statistics in Practice*, Chichester 1996.
- CAPUZZO et al. 2023
- G. CAPUZZO, G. DE MULDER, C. SABAU, S. P. DALLE, M. BOUDIN, R. ANNAERT, M. HLAD, K. SALESSE, A. SENGELOV, E. STAMATAKI, B. VESELKA, E. WARMENBOL, C. SNOECK, M. VERCAUTEREN, Final Neolithic and Bronze Age funerary practices and population dynamics in Belgium, the impact of radiocarbon dating cremated bones, *Radiocarbon* 65, 2023, 51–80.
- CAVAZUTTI et al. 2022
- C. CAVAZUTTI, A. ARENA, A. CARDARELLI, M. FRITZL, M. GAVRANOVIĆ, T. HAJDU, V. KISS, K. KÖHLER, G. KULCSÁR, E. MELIS, K. REBAY-SALISBURY, G. SZABÓ, V. SZEVEÉNYI, The first ‘urnfields’ in the plains of the Danube and the Po, *Journal of World Prehistory* 35, 2022, 45–86. doi: 10.1007/s10963-022-09164-0.
- CHEENEY 1990
- R. F. CHEENEY, Review of: J. C. Davis, *Statistics and Data Analysis in Geology*, New York – Chichester – Brisbane – Toronto – Singapore 1986; D. Marsal, *Statistics for Geoscientists*, Oxford – New York – Beijing – Frankfurt – São Paulo – Sydney – Tokyo – Toronto 1987; R. G. B. Williams, *Intermediate Statistics for Geographers and Earth Scientists*, Basingstoke – London 1986, *Geological Magazine*, 1990, 610–611. doi: 10.1017/S0016756800015624.

- DOBIAT 1994
- C. DOBIAT, Forschungen zu Grabhügelgruppen der Urnenfelderzeit im Marburger Raum. Marburger Studien zur Vor- und Frühgeschichte 17, Marburg 1994.
- EGGERT 2012
- M. K. EGGERT, Prähistorische Archäologie: Konzepte und Methoden. Tübingen 2012.
- EIBNER 1974
- C. EIBNER, Das späturnenfelderzeitliche Gräberfeld von St. Andrä v. d. Hgt., p. B. Tulln, NÖ: Aussagewert und Aussagegrenzen von Brandbestattungen für eine historische Interpretation. *Archaeologia Austriaca*, Beiheft 12, Vienna 1974.
- FAHRNI et al. 2020
- S. M. FAHRNI, J. SOUTHON, B. T. FULLER, J. PARK, M. FRIEDRICH, R. MUSCHELER, L. WACKER, R. E. TAYLOR, Single-year German oak and Californian bristlecone pine ^{14}C data at the beginning of the Hallstatt plateau from 856 BC to 626 BC, *Radiocarbon* 62/4, 2020, 919–937. doi: 10.1017/RDC.2020.16.
- FALKENSTEIN 2017
- F. FALKENSTEIN, Zum Wandel der Bestattungssitten von der Hügelgräber- zur Urnenfelderkultur in Süddeutschland. In: D. BRANDHERM, B. NESSEL (Eds.), *Phasenübergänge und Umbrüche im bronzezeitlichen Europa*. Universitätsforschungen zur prähistorischen Archäologie 297, Bonn 2017, 77–96.
- FRIEMAN 2012
- C. FRIEMAN, Going to pieces at the funeral: completeness and complexity in early Bronze Age jet ‘necklace’ assemblages, *Journal of Social Archaeology* 12/3, 2012, 334–355. doi: 10.1177/1469605311431400.
- FRITZL 2017
- M. FRITZL, Die mehrfach belegten Gräber des Gräberfeldes von Inzersdorf ob der Traisen, NÖ: Eine Studie zu sozialen, religiösen und rituellen Implikationen von mehrfach belegten Gräbern der Urnenfelderkultur. Master’s Thesis, University of Vienna 2017.
- FRITZL et al. 2019
- M. FRITZL, M. KONRAD, K. GRÖMER, A. STADLMAYR, Rituale in der mitteldonauländischen Urnenfelderzeit: Eine Annäherung durch experimentelle Kremationen. In: F. PIELER, E. NOWOTNY (Eds.), *Beiträge zum Tag der Niederösterreichischen Landesarchäologie 2019*. Asparn an der Zaya 2019, 42–54.
- FRITZL et al. 2024
- M. FRITZL, L. WALTENBERGER, H. F. JAMES, C. SNOECK, K. REBAY-SALISBURY, Over the river and into the hills: locals and non-locals at Inzersdorf, a late Bronze Age cemetery in the Traisen Valley (Austria), *Archaeological and Anthropological Sciences* 16, 2024, 151. doi: 10.1007/s12520-024-02054-w.
- FRITZL et al. in prep.
- M. FRITZL, K. GRÖMER, M. KONRAD, A. STADLMAYR, R. HAUBNER, A ritual and taphonomic assessment of grave finds through archaeological experiments, in preparation.
- GATtringer, NEUGEBAUER 1982
- A. GATtringer, J.-W. NEUGEBAUER, Die Kremser Schnellstraße S 33: Vorbericht über Probleme und Ergebnisse der archäologischen Überwachung des Großbauvorhabens durch die Abt. f. Bodendenkmale des Bundesdenkmalamtes, *Fundberichte aus Österreich* 20/1981, 1982, 157–190.
- GATtringer, NEUGEBAUER 1983
- A. GATtringer, J.-W. NEUGEBAUER, Die Kremser Schnellstraße S 33: Zweiter Vorbericht über die Ergebnisse der archäologischen Überwachung des Großbauvorhabens durch die Abt. f. Bodendenkmale des Bundesdenkmalamtes im Jahre 1982, *Fundberichte aus Österreich* 22/1982, 1983, 63–95.
- GILLINGS, HACIGUZELLER, LOCK 2020
- M. GILLINGS, P. HACIGUZELLER, G. LOCK, *Archaeological Spatial Analysis: A Methodological Guide*. Routledge 2020.
- GRAMSCH 2010
- A. GRAMSCH, Ritual und Kommunikation: Altersklassen und Geschlechterdifferenz im spätbronze- und früheisenzeitlichen Gräberfeld Cottbus Alvensleben-Kaserne (Brandenburg). *Universitätsforschungen zur prähistorischen Archäologie* 181, Bonn 2010.
- GRIEBL, BIEDERER 2022
- M. GRIEBL, B. BIEDERER, Die Speichergruben der späturnenfelderzeitlichen Wallanlage von Stillfried an der March: Von der Getreidelagerung bis zur profanen oder kultischen Verfüllung. *Mitteilungen der Prähistorischen Kommission* 92, Vienna 2022.
- GROISS 1976
- F. GROISS, Urnenfelderzeitliche Brandgräber aus Getzersdorf, p.B. St. Pölten, NÖ, *Archaeologia Austriaca* 59–60, 1976, 99–126.
- GROSSKOPF 2004
- B. GROSSKOPF, Leichenbrand – Biologisches und kulturhistorisches Quellenmaterial zur Rekonstruktion vor- und frühgeschichtlicher Populationen und ihrer Funeralpraktiken. PhD Dissertation, University of Leipzig 2004.
- HAHN 2004
- H. HAHN, Global goods and the process of appropriation. In: P. PROBST, G. SPITTLER (Eds.), *Between Resistance and Expansion: Dimensions of Local Vitality in Africa*. *Beiträge zur Afrikaforschung* 18, Münster 2004, 211–231.
- HAMMER, HARPER, RYAN 2001
- O. HAMMER, D. HARPER, P. RYAN, PAST: paleontological statistics software package for education and data analysis, *Palaeontologia Electronica* 4, 2001, 1–9.
- HAMPL, KERCHLER, BENKOVSKY-PIVOVAROVÁ 1985
- F. HAMPL, H. KERCHLER, Z. BENKOVSKY-PIVOVAROVÁ, Das mittelbronzezeitliche Gräberfeld von Pitten in Niederösterreich: Ergebnisse der Ausgrabungen des Niederösterreichischen Landesmuseums in den Jahren 1967 bis 1973 mit Beiträgen über Funde aus anderen Perioden 2: Auswertung. *Mitteilungen der Prähistorischen Kommission* 21–22, Vienna 1985.
- HASTJE, TIBSHIRANI 1990
- T. J. HASTJE, R. J. TIBSHIRANI, *Generalized Additive Models*. *Monographs on Statistics and Applied Probability* 43, Routledge 1990.
- HELGERT 1995
- H. HELGERT, Grabfunde der Čaka-Kultur Bz D/Ha A1-Übergangsperiode aus Zurndorf, p.B. Neusiedl am See, Burgenland: Ein Beitrag zur weiblichen Totentracht, *Archaeologia Austriaca* 79, 1995, 197–248.
- HESS 2013
- M. HESS, Mehrfachbestattungen von der späten Bronze- bis zur frühen Eisenzeit. *Freiburger Archäologische Studien* 6, Rahden/Westfalen 2013.
- HINZ 2009
- M. HINZ, Eine multivariate Analyse Aunjetitzer Fundgesellschaften. *Universitätsforschungen zur prähistorischen Archäologie* 173, Bonn 2009.
- HOFMANN 2013
- K. P. HOFMANN, Gräber und Totenrituale: Zu aktuellen Theorien und Forschungsansätzen. In: M. K. EGGERT, U. VEIT (Eds.), *Theorie in der Archäologie: Zur jüngeren Diskussion in Deutschland*.

- Tübinger archäologische Taschenbücher 10, Münster 2013, 269–298.
- ILON 2015
- G. ILON, Zeitstellung der Urnenfelderkultur (1350/1300–750/700 BC) in West-Transdanubien. Ein Versuch mittels Typochronologie und Radiokarbondaten. In: R. E. NÉMETH, B. REZI (Eds.), *Bronze Age Chronology in the Carpathian Basin. Proceedings of the International Colloquium from Târgu Mureș, 2–4 October 2014*. *Archaeologia* 8, Târgu Mureș 2015, 223–296.
- JENNINGS 2014
- B. JENNINGS, *Travelling Objects: Changing Values – The Role of Northern Alpine Lake-dwelling Communities in Exchange and Communication Networks during the Late Bronze Age*. Oxford 2014.
- JOCKENHÖVEL 1971
- A. JOCKENHÖVEL, *Die Rasiermesser in Mitteleuropa (Süd Deutschland, Tschechoslowakei, Österreich, Schweiz)*. *Prähistorische Bronzefunde* 8/1, Munich 1971.
- KALICZ-SCHREIBER 2010
- R. KALICZ-SCHREIBER, *Ein Gräberfeld der Spätbronzezeit von Budapest-Békásmegyer*. Budapest 2010.
- KAUS 1971
- K. KAUS, Das Hallstatt-A-Gräberfeld von Getzersdorf, p.B. St. Pölten, NÖ, *Archaeologia Austriaca* 50, 1971, 68–112.
- KAUS 1975
- K. KAUS, Das Kriegergrab von Siegendorf. Siegendorf 1975.
- KAUS 1993–1994
- M. KAUS, Ein mittelbronzezeitliches Hügelgrab mit Čaka-Nachbestattungen von Neusiedl-Hutweide, Burgenland, *Mitteilungen der Anthropologischen Gesellschaft in Wien* 123/124, 1993–1994, 89–104.
- KAUS 2006
- K. KAUS, Das Kriegergrab von Siegendorf. In: *Burgenland – Archäologie und Landeskunde: Opera selecta – Ausgewählte Schriften. Wissenschaftliche Arbeiten aus dem Burgenland* 114, Eisenstadt 2006, 40–47.
- KILIAN-DIRLMEIER 1975
- I. KILIAN-DIRLMEIER, Gürtelhaken, Gürtelbleche und Blechgürtel der Bronzezeit in Mitteleuropa (Ostfrankreich, Schweiz, Süddeutschland, Österreich, Tschechoslowakei, Ungarn, Nordwest-Jugoslawien). *Prähistorische Bronzefunde* 12/2, Munich 1975.
- KRAPF 2010
- M. KRAPF, Eine Mehrfachbestattung im „Gründergrab“ 348 von Zuchering-Ost? Neue Ergebnisse der anthropologischen Analyse, *Berichte zur Bayerischen Bodendenkmalpflege* 51, 2010, 49–57.
- KRAPF, WITTWER-BACKOFEN 2011
- M. KRAPF, U. WITTWER-BACKOFEN, Schwertgrab = Mehrfachbestattung? Zur archäo-anthropologischen Auswertung der Schwertgräber von Zuchering-Ost (Stadt Ingolstadt), *Prähistorische Zeitschrift* 86/1, 2011, 85–99. doi: 10.1515/pz.2011.005.
- KRIVORUCHKO, GRIBOV 2019
- K. KRIVORUCHKO, A. GRIBOV, Evaluation of empirical Bayesian kriging, *Spatial Statistics* 32, 2019, 100368. doi: 10.1016/j.spasta.2019.100368.
- LAUERMANN, LINDINGER, HASENHÜNDL 2022
- E. LAUERMANN, V. LINDINGER, G. HASENHÜNDL, Das urnenfelder- und hallstattzeitliche Gräberfeld von Hollabrunn „an der Asperndorferstraße“. *Archäologische Forschungen in Niederösterreich / NF* 9, Krems 2022.
- LIPPERT, STADLER 2009
- A. LIPPERT, P. STADLER, Das spätbronze- und früheisenzeitliche Gräberfeld von Bischofshofen-Pestfriedhof. *Universitätsforschungen zur prähistorischen Archäologie* 168, Bonn 2009.
- LOCHNER 1986
- M. LOCHNER, Das frühurnenfelderzeitliche Gräberfeld von Baierdorf, NÖ, eine Gesamtdarstellung, *Archaeologia Austriaca* 70, 1986, 263–293.
- LOCHNER 1991a
- M. LOCHNER, Ein Gräberfeld der älteren Urnenfelderzeit aus Horn, Niederösterreich, *Archaeologia Austriaca* 75, 1991, 137–220.
- LOCHNER 1991b
- M. LOCHNER, Studien zur Urnenfelderkultur im Waldviertel (Niederösterreich). *Mitteilungen der Prähistorischen Kommission* 25, Vienna 1991.
- LOCHNER 2013
- M. LOCHNER, Bestattungssitten auf Gräberfeldern der mitteldonauländischen Urnenfelderkultur. In: M. LOCHNER, F. RUPPENSTEIN (Eds.), *Brandbestattungen von der mittleren Donau bis zur Ägäis zwischen 1300 und 750 v. Chr.* *Mitteilungen der Prähistorischen Kommission* 77, Vienna 2013, 11–31.
- LOCHNER 2015
- M. LOCHNER, Eine Mehrfachbestattung mit Keramiktrommel aus dem älterurnenfelderzeitlichen Brandgräberfeld von Inzersdorf ob der Traisen, Niederösterreich. In: I. SZATHMÁRI (Ed.), *An der Grenze der Bronze- und Eisenzeit. Festschrift für Tibor Kemeneczi zum 75. Geburtstag*. Budapest 2015, 339–351.
- LOCHNER 2021
- M. LOCHNER, Einleitung. In: M. LOCHNER (Ed.), *Brandbestattung und Bronzemetallurgie: Die Urnenfelderkultur in Niederösterreich (1300–800 v. Chr.)*. *Archäologie Niederösterreichs* 5, Vienna 2021, 20–27.
- LOCHNER, HELLERSCHMID 2008
- M. LOCHNER, I. HELLERSCHMID, Keramische Grundformen der mitteldonauländischen Urnenfelderkultur – Vorschlag für eine Typologie(-grundlage), *Archäologie Österreichs* 19/2, 2008, 45–48.
- LOCHNER, HELLERSCHMID 2016
- M. LOCHNER, I. HELLERSCHMID, *Dokumentation Franzhausen-Kokoron: Ein Gräberfeld der jüngeren Urnenfelderkultur aus Zentraleuropa. Erweiterte interaktive Datenbank mit Illustrationen und Fundbeschreibungen*, Version 03/epub, Vienna 2016. doi: 10.1553/KatalogUfK.
- LÜDEMANN 1994
- H. LÜDEMANN, Mehrfachbelegte Gräber im Frühmittelalter: Ein Beitrag zum Problem der Doppelbestattungen, *Fundberichte aus Baden-Württemberg* 19/1, 1994, 424–589.
- MADSEN 2016
- T. MADSEN, *Multivariate Analyses in Excel using PCA, CA and MS CAPCA, Version 3.1: User Manual*, 2016, <https://www.archaeoinfo.dk/CAPCA%20versions.htm> (last access 4.9.2025).
- MANNING et al. 2018
- S. W. MANNING, C. GRIGGS, B. LORENTZEN, C. BRONK RAMSEY, D. CHIVALL, A. J. T. JULL, T. E. LANGE, Fluctuating radiocarbon offsets observed in the southern Levant and implications for archaeological chronology debates, *Proceedings of the National Academy of Sciences of the United States of America* 115/24, 2018, 6141–6146. doi: 10.1073/pnas.1719420115.

- MAURER 1971
H. MAURER, Ein urnenfelderzeitliches Brandgrab aus Getzersdorf, p.B. St. Pölten, NÖ, *Archaeologia Austriaca* 50, 1971, 115–123.
- McKINLEY 2013
J. I. McKINLEY, Cremation: excavation, analysis, and interpretation of material from cremation-related contexts. In: L. N. STUTZ, S. TARLOW (Eds.), *The Oxford Handbook of the Archaeology of Death and Burial*. Oxford 2013, 147–171.
- MEADOWS et al. 2020
J. MEADOWS, C. RINNE, A. IMMEL, K. FUCHS, B. KRAUSE-KYORA, C. DRUMMER, High-precision Bayesian chronological modeling on a calibration plateau: the Niedertiefenbach Gallery Grave, *Radiocarbon* 62/5, 2020, 1261–1284. doi: 10.1017/RDC.2020.76.
- MONTELIUS 1903
O. MONTELIUS, *Die typologische Methode*. Stockholm 1903.
- MÜLLER-KARPE 1974
H. MÜLLER-KARPE (Ed.), *Beiträge zu italienischen und griechischen Bronzefunden*. *Prähistorische Bronzefunde* 20/1, Munich 1974.
- MÜLLER-SCHEESSEL 2009a
N. MÜLLER-SCHEESSEL, Variabilität und Wandel von Bestattungspraktiken am Beispiel des hallstattzeitlichen Gräberfeldes von Schirndorf, *Ethnographisch-Archäologische Zeitschrift* 50, 2009, 519–537.
- MÜLLER-SCHEESSEL 2009b
N. MÜLLER-SCHEESSEL, Zum Gräberfeld von Schirndorf: ein Beitrag zur Chronologie der Hallstattzeit Nordostbayerns, *Prähistorische Zeitschrift* 84/2, 2009, 191–201.
- MÜLLER-SCHEESSEL 2013
N. MÜLLER-SCHEESSEL, Untersuchungen zum Wandel hallstattzeitlicher Bestattungssitten in Süd- und Südwestdeutschland. *Universitätsforschungen zur prähistorischen Archäologie* 245, Bonn 2013.
- NEUGEBAUER 1996
J.-W. NEUGEBAUER, Eine frühlatènezeitliche Gräbergruppe in Inzersdorf ob der Traisen, NÖ. In: E. JEREM, A. KRENN-LEEB, J.-W. NEUGEBAUER, O. H. URBAN (Eds.), *Die Kelten in den Alpen und an der Donau. Akten des internationalen Symposiums, St. Pölten, 14.–18. Oktober 1992. Studien zur Eisenzeit im Ostalpenraum*, Budapest 1996, 111–178.
- NEUGEBAUER, GATTRINGER 1989
J.-W. NEUGEBAUER, A. GATTRINGER, Rettungsgrabungen im Unteren Traisental im Jahre 1988, *Fundberichte aus Österreich* 27/1988, 1989, 65–97.
- NOVOTNÁ 1980
M. NOVOTNÁ, Die Nadeln in der Slowakei. *Prähistorische Bronzefunde* 13/6, Munich 1980.
- OESTIGAARD 2000
T. OESTIGAARD, The Deceased's Life Cycle Rituals in Nepal: Present Cremation Burials for the Interpretations of the Past. *British Archaeological Reports International Series* 853, Oxford 2000.
- OLSEN et al. 2013
J. OLSEN, J. HEINEMEIER, K. M. HORNSTRUP, P. BENNIKE, H. THRANE, 'Old wood' effect in radiocarbon dating of prehistoric cremated bones? *Journal of Archaeological Science* 40/1, 2013, 30–34. doi: 10.1016/j.jas.2012.05.034.
- ORSCHIEDT 1997
J. ORSCHIEDT, Beispiele für Sekundärbestattungen vom Jungpaläolithikum bis zum Neolithikum, *Ethnographisch-Archäologische Zeitschrift* 38, 1997, 325–345.
- OVERBECK 2018
M. OVERBECK, *Die Gießformen in West- und Süddeutschland (Saarland, Rheinland-Pfalz, Hessen, Baden-Württemberg, Bayern): Alteuropäische Gräber der Kupferzeit, Bronzezeit und Älteren Eisenzeit mit Beigaben aus dem Gießereiwesen (Gießformen, Düsen, Tiegel)*. *Prähistorische Bronzefunde* 19/3, Stuttgart 2018.
- PARE 1998
C. F. E. PARE, Beiträge zum Übergang von der Bronze- zur Eisenzeit in Mitteleuropa, Teil I: Grundzüge der Chronologie im östlichen Mitteleuropa (11.–8. Jahrhundert v. Chr.), *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* 45/1, 1998, 293–433.
- POMBERGER 2009
B. M. POMBERGER, *Das urnenfelderzeitliche Gräberfeld von Mannersdorf am Leithagebirge*. Thesis, University of Vienna 2009.
- PORČIĆ 2013
M. PORČIĆ, The goodness of fit and statistical significance of seriation solutions, *Journal of Archaeological Science* 40/12, 2013, 4552–4559. doi: 10.1016/j.jas.2013.07.013.
- PRESS et al. 1992
W. H. PRESS, S. A. TEUKOLSKY, W. T. VETTERLING, B. P. FLANNERY, *Numerical Recipes in C: The Art of Scientific Computing*. Cambridge – New York – Port Chester – Melbourne – Sydney 1992.
- PRIMAS 2008
M. PRIMAS, *Bronzezeit zwischen Elbe und Po: Strukturwandel in Zentraleuropa 2200–800 v. Chr.* *Universitätsforschungen zur prähistorischen Archäologie* 150, Bonn 2008.
- REBAY-SALISBURY, SØRENSEN, HUGHES 2010
K. REBAY-SALISBURY, M. L. S. SØRENSEN, J. HUGHES (Eds.), *Body Parts and Bodies Whole: Changing Relations and Meanings*. Oxford 2010.
- REIMER et al. 2020
P. J. REIMER, W. E. N. AUSTIN, E. BARD, A. BAYLISS, P. G. BLACKWELL, C. BRONK RAMSEY, M. BUTZIN, H. CHENG, R. L. EDWARDS, M. FRIEDRICH, P. M. GROOTES, T. P. GUILDERSON, I. HAJDAS, T. J. HEATON, A. G. HOGG, K. A. HUGHEN, B. KROMER, S. W. MANNING, R. MUSCHELER, J. G. PALMER, C. PEARSON, J. VAN DER PLICHT, R. W. REIMER, D. A. RICHARDS, E. M. SCOTT, J. R. SOUTHON, C. S. M. TURNER, L. WACKER, F. ADOLPHI, U. BÜNTGEN, M. CAPANO, S. M. FAHRNI, A. FOGTMANN-SCHULZ, R. FRIEDRICH, P. KÖHLER, S. KUDSK, F. MIYAKE, J. OLSEN, F. REINIG, M. SAKAMOTO, A. SOOKDEO, S. TALAMO, The Intcal20 Northern Hemisphere radiocarbon age calibration curve (0–55 cal kBP), *Radiocarbon* 62/4, 2020, 725–757. doi: 10.1017/RDC.2020.41.
- ŘÍHOVSKÝ 1963
J. ŘÍHOVSKÝ, K poznání starší fáze kultury středodunajských popelnicových polí – Velatické kultury (Zur Erkenntnis der älteren Phase der donauländischen Urnenfelderkultur – der Velaticer Kultur), *Sborník Československé Společnosti Archeologické při ČSAV* 3, 1963, 61–115.
- ŘÍHOVSKÝ 1965
J. ŘÍHOVSKÝ, Das Urnengräberfeld von Klentnice. *Fontes archaeologici Pragenses* 8, Prague 1965.
- ŘÍHOVSKÝ 1968
J. ŘÍHOVSKÝ, Das Urnengräberfeld in Oblekovice. *Fontes archaeologici Pragenses* 12, Prague 1968.
- ŘÍHOVSKÝ 1972
J. ŘÍHOVSKÝ, Die Messer in Mähren und dem Ostalpengebiet. *Prähistorische Bronzefunde* 7/1, Munich 1972.

- ŘÍHOVSKÝ 1979
J. ŘÍHOVSKÝ, Die Nadeln in Mähren und im Ostalpengebiet. Prähistorische Bronzefunde 13/5, Munich 1979.
- ŘÍHOVSKÝ 1982
J. ŘÍHOVSKÝ, Das Urnengräberfeld von Podolí. *Fontes archaeologicae Moraviae* 15, Brno 1982.
- ŘÍHOVSKÝ 1993
J. ŘÍHOVSKÝ, Fibeln in Mähren. *Prähistorische Bronzefunde* 14/9, Stuttgart 1993.
- RINGROSE 1992
T. J. RINGROSE, Bootstrapping and correspondence analysis in archaeology, *Journal of Archaeological Science* 19/6, 1992, 615–629. doi: 10.1016/0305-4403(92)90032-X.
- ROSE, MEADOWS, HENRIKSEN 2020
H. A. ROSE, J. MEADOWS, M. B. HENRIKSEN, Bayesian modeling of wood-age offsets in cremated bone, *Radiocarbon* 62/2, 2020, 379–401. doi: 10.1017/RDC.2020.3.
- ROSE et al. 2022
H. A. ROSE, N. MÜLLER-SCHESSEL, J. MEADOWS, C. HAMANN, Radiocarbon dating and Hallstatt chronology: a Bayesian chronological model for the burial sequence at Dietfurt an der Altmühl ‘Tennisplatz’, Bavaria, Germany, *Archaeological and Anthropological Sciences* 14, 2022, 72. doi: 10.1007/s12520-022-01542-1.
- ROTHER, FISCHER 2018
N. ROTHER, S. FISCHER, Reclaiming Arnold Van Gennep’s *Les rites de passage* (1909): The structure of openness and the openness of structure, *Journal of Classical Sociology* 18/4, 2018, 255–265. doi: 10.1177/1468795X18789010.
- SABAUX et al. 2021
C. SABAUX, B. VESELKA, G. CAPUZZO, C. SNOECK, A. SENGELØV, M. HLAD, E. WARMBOL, E. STAMATAKI, M. BOUDIN, R. ANNAERT, S. DALLE, K. SALESSE, V. DEBAILLE, D. TYS, M. VERCAUTEREN, G. DE MULDER, Multi-proxy analyses reveal regional cremation practices and social status at the Late Bronze Age site of Herstal, Belgium, *Journal of Archaeological Science* 132, 2021, 105437. doi: 10.1016/j.jas.2021.105437.
- SABAUX et al. 2024
C. SABAUX, C. SNOECK, G. CAPUZZO, B. VESELKA, S. DALLE, E. WARMBOL, E. STAMATAKI, M. HLAD, A. SENGELØV, V. DEBAILLE, M. BOUDIN, K. SALESSE, R. ANNAERT, M. VERCAUTEREN, G. DE MULDER, Novel multidisciplinary approach detects multiple individuals within the same Late Bronze-Early Iron Age cremation graves, *Radiocarbon* 66/4, 2024, 761–773. doi: 10.1017/RDC.2024.82.
- SCHUMANN et al. 2023
R. SCHUMANN, M. AUGSTEIN, J. FRIES-KNOBLACH, S. GENTNER, M. KIRCHMAYR, M. KOHLE, H. WENDLING (Eds.), *Eisenzeitliche Erinnerungskulturen: Zum Umgang eisenzeitlicher Gemeinschaften mit Relikten der Vergangenheit. Beiträge zur Jahressitzung der AG Eisenzeit auf dem Deutschen Archäologiekongress in Kiel vom 23.–24. September 2020 (online-Tagung). Beiträge zur Ur- und Frühgeschichte Mitteleuropas* 107, Langenweißbach 2023.
- SCHÜTZ 2007
C. SCHÜTZ (Ed.), *Das urnenfelderzeitliche Gräberfeld von Zuchering-Ost, Stadt Ingolstadt. Materialhefte zur bayerischen Vorgeschichte* 90, Kallmünz 2007.
- SEEBER-KNEUSSL 1990
S. SEEBER-KNEUSSL, *Das urnenfelderzeitliche Gräberfeld von Ampaß-Sonnbichl. Thesis, University of Innsbruck* 1990.
- SHENNAN 1988
S. SHENNAN, *Quantifying Archaeology*. Edinburgh 1988.
- SKERJANZ 2024
H. SKERJANZ, *Die mittelbronzezeitlichen Hügel- und Brandgräber von Unterradlberg: ein multidisziplinärer Ansatz zur Untersuchung von Brandbestattungen. Master’s Thesis, University of Vienna* 2024.
- SNOECK, BROCK, SCHULTING 2014
C. SNOECK, F. BROCK, R. J. SCHULTING, Carbon exchanges between bone apatite and fuels during cremation: impact on radiocarbon dates, *Radiocarbon* 56/2, 2014, 591–602.
- SOHIL, SOHAIL, SHABBIR 2022
F. SOHIL, M. SOHAIL, J. SHABBIR, Review of: G. James, D. Witten, T. Hastie, R. Tibshirani, *An introduction to statistical learning with applications in R*, New York 2013, *Statistical Theory and Related Fields* 6/1, 2022, 87. doi: 10.1080/24754269.2021.1980261.
- SØRENSEN, REBAY-SALISBURY 2023
M. L. S. SØRENSEN, K. REBAY-SALISBURY, *Death and the Body in Bronze Age Europe: From Inhumation to Cremation*. Cambridge – New York – Port Melbourne – New Delhi – Singapore 2023.
- STADLER 2005
P. STADLER, *Quantitative Studien zur Archäologie der Awaren I. Mitteilungen der Prähistorischen Kommission* 60, Vienna 2005.
- STOCKHAMMER 2011
P. W. STOCKHAMMER, Conceptualizing cultural hybridization in archaeology. In: P. W. STOCKHAMMER (Ed.), *Conceptualizing Cultural Hybridization: A Transdisciplinary Approach*. Transcultural Research – Heidelberg Studies on Asia and Europe in a Global Context, Berlin – Heidelberg 2011, 43–58.
- TERŽAN, ČREŠNAR 2014
B. TERŽAN, M. ČREŠNAR, *Absolutno datiranje bronaste in železne dobe na Slovenskem / Absolute Dating of the Bronze and Iron Ages in Slovenia*. Katalogi in monografije 40, Ljubljana 2014.
- THEUNE 1995
C. THEUNE, Möglichkeiten und Grenzen der Seriation: Ein Diskussionsbeitrag, *Ethnographisch-Archäologische Zeitschrift* 2, 1995, 323–341.
- TOBLER 1970
W. R. TOBLER, A computer movie simulating urban growth in the Detroit region, *Economic Geography* 46, 1970, 234–240. doi: 10.2307/143141.
- TOČÍK, PAULÍK 1960
A. TOČÍK, J. PAULÍK, *Výskum mohyly v Čake v rokoch 1950–51 (Die Ausgrabung eines Grabhügels bei Čaka in den Jahren 1950–51)*, *Slovenská Archeológia* 8, 1960, 59–124.
- TRACHSEL 2004
M. TRACHSEL, Untersuchungen zur relativen und absoluten Chronologie der Hallstattzeit. *Universitätsforschungen zur prähistorischen Archäologie* 104, Bonn 2004.
- TRNKA, LADENBAUER-OREL 1992
G. TRNKA, H. LADENBAUER-OREL, *Das urnenfelderzeitliche Gräberfeld von Gusen in Oberösterreich*, *Archaeologia Austriaca* 76, 1992, 47–112.
- TURNER 1969
V. TURNER, *The Ritual Process: Structure and Anti-Structure*. New Brunswick – London 1969.
- VAN GENNEP 1909
A. VAN GENNEP, *Les rites de passage*. Paris 1909.

- VAN STRYDONCK 2016
M. VAN STRYDONCK, Radiocarbon dating of cremated bones: an overview. In: G. GRUPE, G. C. MCGLYNN (Eds.), *Isotopic Landscapes in Bioarchaeology*. Berlin – Heidelberg 2016, 69–89.
- VAN STRYDONCK, BOUDIN, DE MULDER 2010
M. VAN STRYDONCK, M. BOUDIN, G. DE MULDER, The carbon origin of structural carbonate in bone apatite of cremated bones, *Radiocarbon* 52/2, 2010, 578–586. doi: 10.1017/S0033822200045616.
- WAHL 1982
J. WAHL, Leichenbranduntersuchungen: Ein Überblick über Bearbeitungs- und Aussagemöglichkeiten von Brandgräbern, *Prähistorische Zeitschrift* 57/1, 1982, 1–125.
- WAHL 1994
J. WAHL, Zur Ansprache und Definition von Sonderbestattungen. In: M. KOKABI, J. WAHL (Eds.), *Beiträge zur Archäozoologie und Prähistorischen Anthropologie. Forschungen und Berichte zur Vor- und Frühgeschichte Baden-Württemberg* 53, Stuttgart 1994, 85–106.
- WALTENBERGER et al. 2023
L. WALTENBERGER, M. D. BOSCH, M. FRITZL, A. GAHLEITNER, C. KURZMANN, M. PINIEL, R. B. SALISBURY, L. STRNAD, H. SKERJANZ, D. VERDIANU, C. SNOECK, F. KANZ, K. REBAY-SALISBURY, More than urns: a multi-method pipeline for analyzing cremation burials, *PLOS ONE* 18/8, 2023, e0289140. doi: 10.1371/journal.pone.0289140.
- WEBSTER 2021
L. WEBSTER, Synchronising the Chronologies of the Late Bronze Age Southern Levant and Egypt: A Radiocarbon Dating Perspective. PhD Dissertation, Vienna 2021.
- WEISS-KREJCI 2001
E. WEISS-KREJCI, Restless corpses: ‘secondary burial’ in the Babenberg and Habsburg dynasties, *Antiquity* 75, 2001, 769–780.
- WEISS-KREJCI 2013
E. WEISS-KREJCI, The unburied dead. In: S. TARLOW, L. NILSSON STUTZ (Eds.), *The Oxford Handbook of the Archaeology of Death and Burial*. Oxford 2013, 281–301.
- WELS-WEYRAUCH 1991
U. WELS-WEYRAUCH, Die Anhänger in Südbayern. *Prähistorische Bronzefunde* 11/5, Stuttgart 1991.
- WENINGER, JUNG 2009
B. WENINGER, R. JUNG, Absolute chronology of the end of the Aegean Bronze Age. In: S. DEGER-JALKOTZY, A. BAECHLE (Eds.), *LH IIIC Chronology and Synchronisms III: LH IIIC Late and the Transition to the Early Iron Age*. Proceedings of the International Workshop at the Austrian Academy of Sciences at Vienna, February 23rd and 24th, 2007. Veröffentlichungen der Mykenischen Kommission 30, Vienna 2009, 373–416.
- WENINGER, KRAUSS 2024
B. WENINGER, R. KRAUSS, Pottery dating by correspondence analysis. In: J. DRIESSEN, T. FANTUZZI (Eds.), *Chronos: Stratigraphic Analysis, Pottery Seriation and Radiocarbon Dating in Mediterranean Chronology*. Aegis – Actes de colloques 26, Louvain-la-Neuve 2024, 31–55.
- WIESNER 2009
N. WIESNER, Grabbau und Bestattungssitten während der Urnenfelderzeit im südlichen Mitteleuropa: Ein Beitrag zur Entwicklung der Grabsitten in der späten Bronzezeit. *Internationale Archäologie* 110, Rahden/Westfalen 2009.
- WIRTH 1999
S. WIRTH, Auf der Suche nach Eliten der späten Bronzezeit und der Urnenfelderzeit: Bausteine zum Thema aus dem Altsiedelland am unteren Lech in Bayerisch-Schwaben. In: *Eliten in der Bronzezeit*. Ergebnisse zweier Kolloquien in Mainz und Athen. Monographien des Römisch-Germanischen Zentralmuseums 43/1, Mainz 1999, 565–604.
- WOJCIESZAK et al. 2020
M. WOJCIESZAK, T. VAN DEN BRANDE, G. LIGOVICH, M. BOUDIN, Pretreatment protocols performed at the Royal Institute for Cultural Heritage prior to AMS ¹⁴C measurements, *Radiocarbon* 62/5, 2020, e14–e24. doi: 10.1017/RDC.2020.64.

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