SPRAWOZDANIA ARCHEOLOGICZNE TOM 77/1 (2025), PP. 21-51

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PL ISSN 0081-3834; e-ISSN: 2719-647X

DOI: https://doi.org/10.23858/SA77.2025.1.4127

https://rcin.org.pl/dlibra/publication/299719

SPRAWOZDANIA ARCHEOLOGICZNE 77/1, 2025
PL ISSN 0081-3834
DOI: 10.23858/SA/77.2025.1.4127

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BURIAL CUSTOMS AND CULTURAL CHANGE. A CASE STUDY FROM CENTRAL GERMANY DURING THE TRANSITION FROM THE LATE BRONZE AGE TO THE EARLY IRON AGE

ABSTRACT

Korczyńska-Cappenberg M. 2025. Burial Customs and Cultural Change. A Case Study from Central Germany during the Transition from the Late Bronze Age to the Early Iron Age. *Sprawozdania Archeologiczne* 77/1, 21-51.

This paper presents the osteological, taphonomic, and archaeological analysis of a cremation grave from Markranstädt in northwestern Saxony – a region situated at the intersection of three cultural traditions during the final phase of the Late Bronze Age and the older phase of the Early Iron Age. Although the burial lacked distinctive grave goods, typochronological multivariate statistics provided a chronological and cultural framework for interpretation. Osteological analysis identified the deceased as an adult aged 30-40 years, exhibiting a notably tall stature and no pathological alterations in the skeletal remains. Taphonomic evidence reveals a deliberate and structured arrangement of the cremated bones within the urn, including the vertical, antithetical positioning of lower limb epiphyses and the horizontal placement of upper limb elements. These findings enhance our understanding of funerary practices in the region, highlighting the ritual complexity of cremation burials during this period of cultural transition.

Keywords: Late Bronze Age, Early Iron Age, funerary practices, Central Europe, osteological analysis, multivariate statistics
Received: 05.05.2025; Revised: 29.05.2025; Accepted: 29.09.2025

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INTRODUCTION

Robert Hertz, in his seminal 1907 essay 'A Contribution to the Study of the Collective Representation of Death', was among the first to recognise that for indigenous peoples, death is not a discrete event but an extended process of transformation. Subsequently, Arnold van Gennep's groundbreaking work 'Les Rites de Passage' (1909) classified funerary rituals as rites of passage, delineating three fundamental stages within that process: separation (preliminal), liminality (marginal), and aggregation – the reintegration into the social community (postliminal).

While these pioneering studies were based on ethnographic observation and were not contextualised within archaeological data, they addressed the universal, deeply traumatic human experience of death that transcends cultural and temporal boundaries. Notably, no society fails to develop complex and varied practices for engaging with the deceased. From the sociological perspective, death constitutes a transition in which an individual relinquishes social roles and, through ritual performance, is transformed into an ancestor who, in the afterlife, sustains the wellbeing of the living community (*cf.*, van Gennep 2005; Brandt 2011, 71; Gramsch 2010, 141; Hofmann 2008, 369, 370; Korczyńska *et al.* 2016; Veit 2013, 12, 13). Beyond private mourning and transition rites, funerary ritual serves pivotal social functions for the living community by reinforcing kinship bonds, enhancing group cohesion, and facilitating differentiation from external groups (*cf.*, Benz and Gramsch 2006, 430; Hofmann 2008, 369).

Funeral customs generally adhere to clearly articulated regulations; yet, each ritual act exhibits unique variations reflective of individual and local agency. Such variability is manifested in the archaeological record as a diversity of burial customs within and between cemeteries. However, it is imperative to acknowledge that graves rarely offer a direct mirror of social reality. Instead, they encode ideological frameworks – religious, social, and political beliefs and norms (Brandt 2011, 72; Gramsch 2005, 3; 2010, 123-134). Furthermore, interpreting prehistoric funerary customs demands a conscious effort to transcend modern conceptions of death. A task that remains, for us, almost insurmountable due to the substantial cultural and temporal distance separating contemporary perspectives from those of the past.

Within this theoretical framework, the present study turns to a recently investigated singular burial in the scarcely explored region north of Markranstädt, district of Leipzig, northwestern Saxony. Here, archaeological rescue excavations initiated in 2019 by the Saxon State Office for Archaeology shed new light on local settlement dynamics. During the excavations, three new archaeological sites have been uncovered and documented. The present article focuses on an excavation area uncovered in 2020 at activity MS-129, and, more particularly, on the urn grave found there, which was thoroughly examined through micro-excavations (Kretzschmar and Korczyńska-Cappenberg 2024). The core research questions guiding this investigation are as follows: Is it possible to determine an individual's stature and sex from cremated remains when bone fragments are analysed in detail and organised into larger units? Furthermore, have micro-excavations revealed discernible patterns or rules governing the spatial arrangement and deposition of cremated human remains within the urn, reflecting intentionality and thus representing the postliminal transition phase, an integral element of burial customs?

To address these questions, an intensive excavation method was employed, involving meticulous documentation of the position of every individual bone fragment. Such analyses are exceptionally labour- and time-intensive and remain extraordinarily rare within both Late Bronze Age and Early Iron Age contexts. Previous studies in this domain have either failed to reveal consistent patterns in bone placement (*e.g.*, Waltenberger *et al.* 2023), produced limited, albeit groundbreaking, observations (Gramsch 2010), or provided only basic spatial information (Pankowská *et al.* 2017).

The present paper thus contributes novel data, advancing our understanding of at least some urn burial practices in this region and demonstrating the potential of detailed micro-excavation, combined with osteological and taphonomic analyses, as tools for elucidating prehistoric funerary traditions.

MATERIALS AND METHODS

Geographical location of the site and fieldwork

Markranstädt is located in the northwestern part of Saxony, within the Leipzig Basin, a gently undulating loess-loam-covered lowland that forms part of the Central German loess zone. The area lies at an elevation of approximately 120-140 metres above sea level.

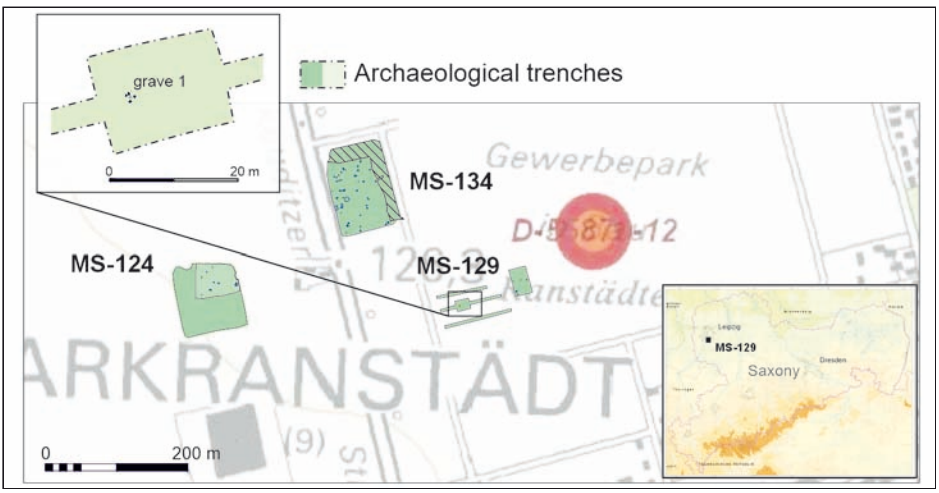

Fig. 1. Location of the grave at Markranstädt-129 (MS-129)

It is characterised by fertile loess soils derivates (German typology: 'Parabraunerde'), with the nearby Saale, Weiße Elster and Luppe rivers forming the current hydrological background (together with some lakes that are remnants of lignite mining in the region).

Before the planned construction work in the northern part of the city, in 2019, the area was archaeologically examined through test trenches (Fig. 1). In the eastern part of the site, several features likely representing settlement remains were documented, while in the central area, an isolated urn grave was identified. Following its discovery, the excavation area surrounding the grave was expanded, but no further graves were found, confirming its singular nature. Four large stones surrounded the urn, but no clear grave pit or indications of a burial mound were detected (Fig. 2: A). The urn was subsequently retrieved using a block recovery and further examined under laboratory conditions.

Cultural background of the study area

The Northwestern Saxony region lies in a border zone where multiple archaeological cultures and groups (in the sense of the cultural-historical approach) intersect. This intricate cultural diversity makes it difficult to assign a precise chronological context and suggests that the burial at Markranstädt may potentially exhibit overlapping influences from adjacent cultural traditions. Understanding these interactions and regional diversity is crucial for interpreting the burial's unique features and assessing its place within broader socio-cultural transformations occurring at the time.

During the final phase of the Late Bronze Age and the transition into the Early Iron Age (Ha B2-Ha B3/Ha C, approx. 900-780 BC), in northwestern Saxony, the horizontally grooved pottery style of the late Lusatian Culture predominated (Fig. 2: A). However, due to its peripheral location, the area also exhibited influences from the so-called Saalemündung group, which originated in eastern Saxony-Anhalt as well as from the Unstrut group

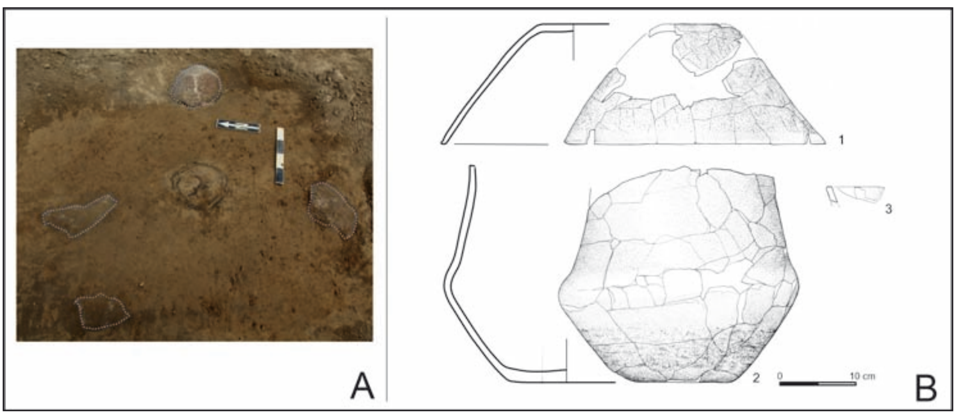

Fig. 2. Markranstädt-129, Grave 1: photographic documentation in the field (A) and pottery inventory (B)

of the northern Thuringian Basin (*e.g.*, Heynowski 2010). The burial customs within the later Lusatian Culture are generally considered comparatively uniform, with quite elaborate urn graves. Also, in both the Saalemündung and Unstrut groups, cremation was the predominant practice. However, within the Unstrut group, several inhumation graves also occur, interpreted as a continuation of older burial traditions. In northwest Saxony during the Late Bronze Age, a moderate variety of grave types can be observed. This ranges from classic urn graves with burial pits and few grave goods, to (presumed) chamber graves, cremation pit graves, and isolated so-called bell-rimmed graves (German: 'Glockengräber', *cf.*, *e.g.*, Battaune; Schmalfuß 2015/2016). This variance reflects the region's peripheral position within the broader Urnfield complex.

In the subsequent phase (Ha C, approx. 780-620 BC), unlike in eastern Saxony, where the Lusatian culture transitioned into the Billendorf culture, the transition from the Late Bronze Age to the Early Iron Age remains unclear (Ender 2009, 158; Döhlert-Albani 2025, 24). There is no evidence of a continuous Billendorf cemetery or settlement to the west of the Elbe River, which spans both the final stage of the Late Bronze Age and the older phase of the Early Iron Age. Instead, in northwestern Saxony, three cultural groups intersected and partially overlapped: the western group of the older Billendorf Culture, which extended along the Elbe corridor; the House Urn Culture between Elbe and Saale rivers and the Thuringian Culture in Thuringia Basin and in Saxony-Anhalt along the Saale, Weiße Elster, and Pleiße rivers (Fig. 3: B; Peschel 1990; Döhlert-Albani 2025; see also further references therein). For this region, R. Heynowski (2007) proposed the existence of an independent Northwestern Saxon Group. Based on analysis of grave characteristics and inventories from the cemetery at Zwenkau-Nord, he concluded that this group cannot be clearly assigned to any of the adjacent Early Iron Age cultural units. However, certain finds and burial customs could be attributed to the styles known from the surrounding regions. In the Billendorf cemetereies an extensive ceramic assemblage – comprising many small

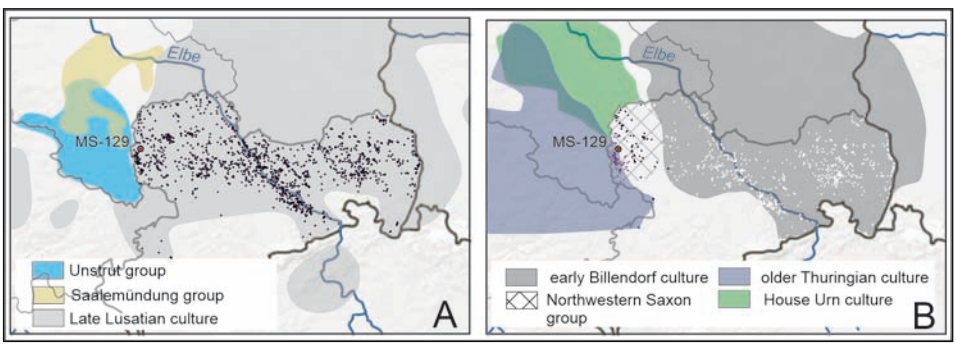

Fig. 3. Extent of the archaeological cultures in Central Germany during the final phase of the Late Bronze Age (A; Ha B2-Ha B3/Ha C, *ca*. 900-750 BC) and older stage of the Early Iron Age (B; Ha C-Ha D1, *ca*. 750-550 BC) (after Buck 1979; Heynowski 2010; Meller 2015; Peschel 1992, modified)

and large vessels – was placed in the grave alongside the urn (*cf.*, Kaiser and Manchus 2017), while Early Iron Age burials of the Northwestern Saxon Group usually consisted of individual urn graves accompanied by one or two additional vessels. This burial custom shows remarkable parallels to the funeral traditions in the areas to the west and northwest. Because of the relatively uniform grave inventories, it might be assumed that generally the community that settled Northwest Saxony at that time might be described as egalitarian. Burials that could be interpreted from our current perspective as rich were only very occasionally found in the Leipzig and Halle regions (*cf.*, Heynowski 2007, 120; Müller 1993). The Northwestern Saxon Group continued to develop in Saxony with those distinctly independent traits throughout the entire Iron Age.

Methods of micro-excavation and documentation of the materials

Following the identification of the urn burial in the field, the grave context, including the urn and its immediate surroundings, was excavated as a single soil block under the supervision of the appointed head of rescue excavation, Sven Kretzschmar. This includes not only the urn itself and its contents, but also the surrounding grave pit and adjoining sediment. This block was subsequently stabilised using a gypsum plaster jacket to preserve the original stratigraphy and spatial relationships of its contents. Such an approach enabled detailed micro-excavation and in-lab analysis of the cremated remains, associated pottery fragments, and sediment layers within the urn, providing a comprehensive starting point for understanding the grave assemblage and for further investigation into individual funerary customs.

The micro-excavation within the urn was conducted following the natural stratigraphy. The urn was filled with a clay-loess sediment that required very careful moistening to allow digging and to enhance the visibility of the bones without compromising the integrity of the fragile bone spongiosa. All bone remains and pottery finds were individually numbered and documented *in situ*. A new layer was excavated whenever several new finds became visible, and the border of the osteological and archaeological material could be recognised. In order to detect possible charred macro remains and/or charcoals, all sediment from the urn and from the grave pit was floated with sieves of 0.5 mm and 1 mm mesh diameter.

Osteological methods

Anatomical and taphonomic analyses were carried out on skeletal and dental fragments larger than 4 mm, which were manually separated during excavation. The smaller fraction (<4 mm) was excluded from further analysis. The anatomical identification of the bone fragments, their state of preservation (maximum length and width, weight), and any pathological changes were determined. Bone fragments with matching fracture edges were refitted and subsequently measured as a unit in order to study taphonomy of the cremated remains and osteological issues.

For complete long bones, unburned metric references were taken from Gonçalves (2011) and Gonçalves *et al.* (2020). Sex estimation was then conducted using the methods proposed by Mall *et al.* (2001). To verify the sex estimations, measurements of calcined remains were compared with experimental data published by Gonçalves (2011) and with sex estimations from cremated remains in Late Bronze Age and Iron Age cemeteries in Italy, as analysed by Cavazzutti *et al.* (2019). In addition, the method developed by Gonçalves *et al.* (2013) was applied to some remains.

To estimate the stature of the individual, a reconstruction of pre-burning bone metrics was carried out using the results of experimental studies by Gonçalves (2011) and Gonçalves *et al.* (2020). Subsequently, the equation proposed by Trotter (1970) and, additionally, the Rösing method (1977) were used.

Methods of the statistical approaches to the typochronological classification of the grave from Markranstädt

The inventory of the Markranstädt grave consisted essentially of two vessels: a biconical vase and a conical bowl. To assess the statistical affiliation of the vessel used as the urn with a formal archaeological group, multivariate statistical analyses were conducted. For this purpose, a reference database of undecorated vases from Saxony, southeastern Saxony-Anhalt, and eastern Thuringia was compiled (51 cases in total; see Table 1 in Suppl. data). In each case, such measurements as:

H1 – Maximum vessel height;
H2 – Height from the rim to the maximum belly width;
H3 – Height from the bottom to the maximum belly width;
H4 – Height of the shoulder zone;
W1 – Rim diameter;
W2 – Maximum vessel width (corresponding to the maximum belly width);
W3 – Bottom diameter;
W4 – Neck diameter just above the shoulder was taken.

From these measurements, the following proportions were calculated: belly position and slenderness → H1/W2, H3/H1; mouth shape → W1/W2, W4/W2; overall appearance → combination of H1/W2, W3/W2, H4/H1. Subsequently, a Principal Component Analysis (PCA) was performed using the Past version 5.2.1 based on a correlation matrix in which variables that showed strong positive correlations were excluded from the analysis to avoid redundancy.

RESULTS

Typo-chronological classification of the grave inventory

The grave inventory comprises two vessels: a large, undecorated vase with a conical neck and a gently curved profile, serving as the container for the cremated remains, and a conical bowl that covered the burial (Fig. 2: B). The urn vessel was tempered with mineral inclusions and fired in an oxidising atmosphere. Both its interior and exterior surfaces were smoothed, with the lower portion of the exterior intentionally left rough. The bowl exhibits comparable technological traits, with its outer surface deliberately roughened by a brush technique extending to approximately one centimetre below the rim.

While conical bowls are present throughout the Late Bronze Age in Central Germany, they notably increase in frequency during the younger phase of the Billendorf Culture (*e.g.*, Buck 1979; 1989; *cf.*, Fig. 2: B). The Markranstädt vessel remains undecorated. Reconstructing the typochronological development of this vessel type solely on the basis of profile features is challenging. Conical-neck vases appear in Central Germany from the Middle Bronze Age onward. In general, their later iterations show a decline in pronounced profiling and a decrease in incised decoration towards the end of the Bronze Age (*cf.*, Buck 1979, 1989). The straightforward comparison of vases resembling the Markranstädt vessel suggests close parallels to pieces found in Middle Saxony, including cemeteries such as Dresden-Stetzsch (Coblenz 1985, pl. 37.10, 40.9, 57.19), Altlommatzsch (Hellström 2005, *e.g.*, Graves 57, 158 and 243), and Liebersee (Bemman and Wesely-Arents 2005, pls 33.20-21, 76.22; Ender 2003, pls 5.7, 12.36, 29.1, 50.5, 71.9). But on the other hand, strong analogies exist with the immediately adjacent western regions as well, particularly with a vessel from an Unstrut group cemetery in Obermöllern (southeast Saxony-Anhalt, Wagner 1992, fig. 53.15; see fig. 5.14). Taken together, neither the urn nor the covering bowl displays distinctive typological features sufficient for precise cultural and chronological attribution.

For that reason, an attempt was made to apply multivariate statistical analysis of the urn for further examination of its typological affinities (Fig. 4). Although it is generally assumed that the proportions of robust, handmade vessels primarily reflect stylistic traditions maintained at the household level by local workshops, it has nevertheless been demonstrated that similarities in vessel form may also reflect continuity or discontinuity in the style development or suggest local network connections (*cf.*, Przybyła and Dzięgielewski eds 2024).

In the case of the urn from Markranstädt, Principal Component 1 (PC1) explains 32.41% of the variance and shows positive correlations with the following vessel ratios: 1) the ratio, showing how high the belly is and 2) the ratio providing insights into the design of the neck/shoulder area, and negative correlations to the ratio, that describes the opening relative to the maximum width. Principal Component 2 (PC2) explains 27.43% of the variance, with positive correlations to 1) the ratio, that shows whether a vessel is tall and slender or squat and 2) the ratio describing whether the vessel is narrow- or wide-mouthed and a negative correlation with neck diameter just above the shoulder/maximum vessel width (the ratio showing if neck is narrow or wide).

Both axes of the plot likely reflect chronological depth, as most of the Early Iron Age vases are clustered right to the PC1 axis of the diagram (Fig. 4: A). The vessel from Markranstädt,

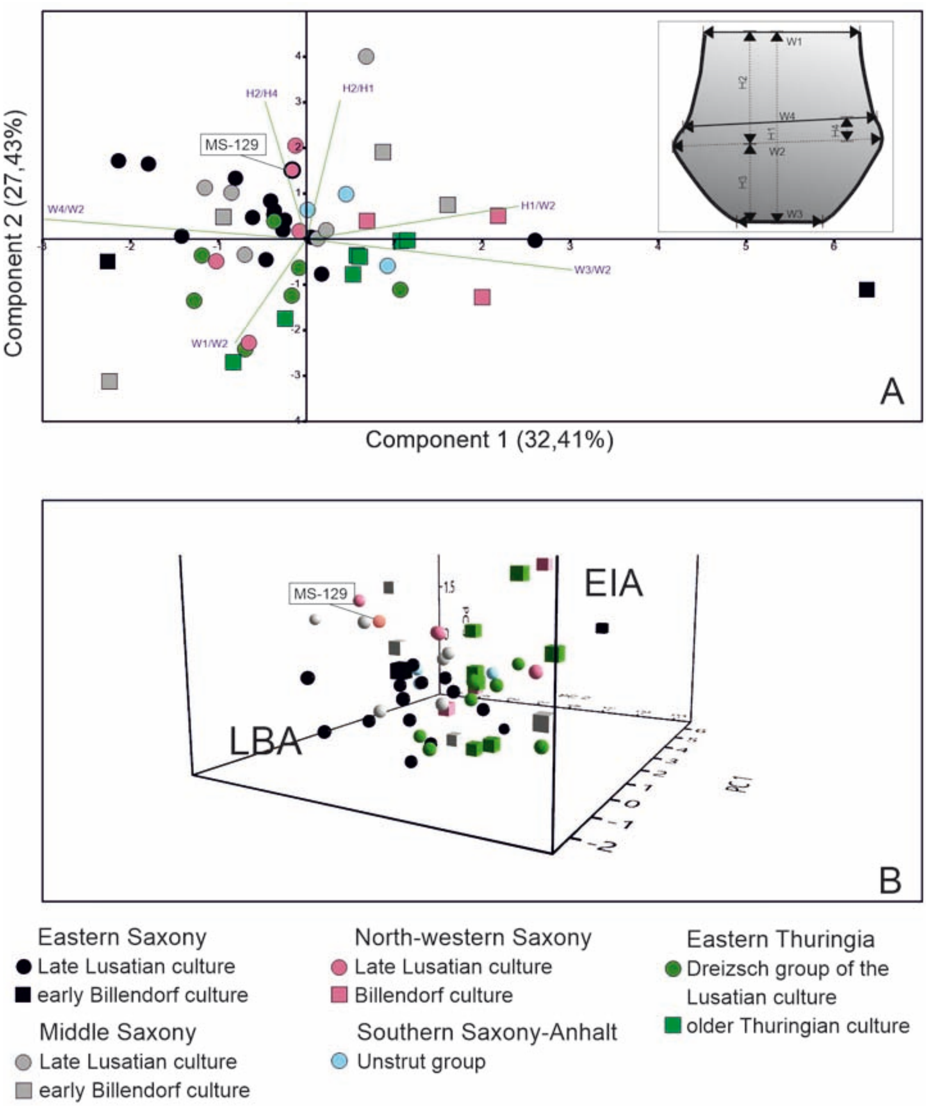

Fig. 4. Plot of the PC1 and PC2 of the Principal Components Analysis (A) and 3D visualisation (B) of undecorated vessels of 'terrine' type from the Late Bronze Age and Early Iron Age sites located in Central Germany

together with Late Bronze Age vessels from northwestern Saxony, is positioned to the left of the PC1 axis and closely clusters with vessels from the Middle Saxony region. This spatial placement indicates that the urn shares the same stylistic tradition with vases from the Late Bronze Age Lusatian culture of Middle Saxony. At the same time, Early Iron Age vessels from eastern Thuringia in both periods form a distinct, separate cluster. This allows the grave to be placed within the Late Bronze Age Lusatian ceramic tradition and indicates a close interaction network within the Saxony region during the Late Bronze Age.

Results of micro-excavation

A total of 15 stratigraphic layers were excavated and documented using orthophotogrammetry based on the Structure from Motion (*SfM*) technique (Fig. 5). The urn's fill containing the cremated remains appears to have been relatively loose, as the burnt bones were embedded in substantial amounts of redeposited loess sediment. In the upper layers of the urn (Layers 1 and 3-5), fragments of the base and rim of a conical bowl were discovered. Additionally, six small pottery sherds were recovered from deeper layers among the bones, attributable to two further Late Bronze Age/Early Iron Age vessels, including a rim fragment with a conical profile (Fig. 2: B) and a body sherd from a thin-walled vessel. The precise timing of these fragments' entry into the urn remains unclear. Since no additional vessels were found in the immediate vicinity of the urn, it is conceivable that the sherds may represent the remains of libation rituals performed during the burial ceremony (*cf.,* Gramsch 2005; Nebelsick 2000; 2018, with further references). However, it cannot be ruled out that the sherds entered the urn post-depositionally through erosion of the surrounding cultural layer or, less likely, through bioturbation. Nevertheless, no settlement remains have been identified in the immediate vicinity of the grave that could have served as the source of these ceramic fragments. For that reason, this question is still open.

Numerous recent seeds of white goosefoot (*Chenopodium album*) were also found inside the urn, probably introduced by bioturbation or via re-deposited sediment. A recent seed of ivy-leaved speedwell (*Veronica hederifolia*) was recovered from Layer 13. Those macroremains should be interpreted as the result of macrofaunal activity, which impacts stratigraphy and sometimes even fragmentation of cremated bones (*e.g.*, Hałuszko *et al.* 2022). In contrast to recent intrusions, four small fragments of charcoal found in direct contact with the bones are plausibly remnants of the pyre. They represent oak (*Quercus* sp.), pine (*Pinus* sp.), hazel (*Corylus avellana*), and an undetermined conifer species. The fact that only four tiny charcoal fragments were recovered suggests that the cremated bones were very carefully collected from the pyre and probably washed afterwards.

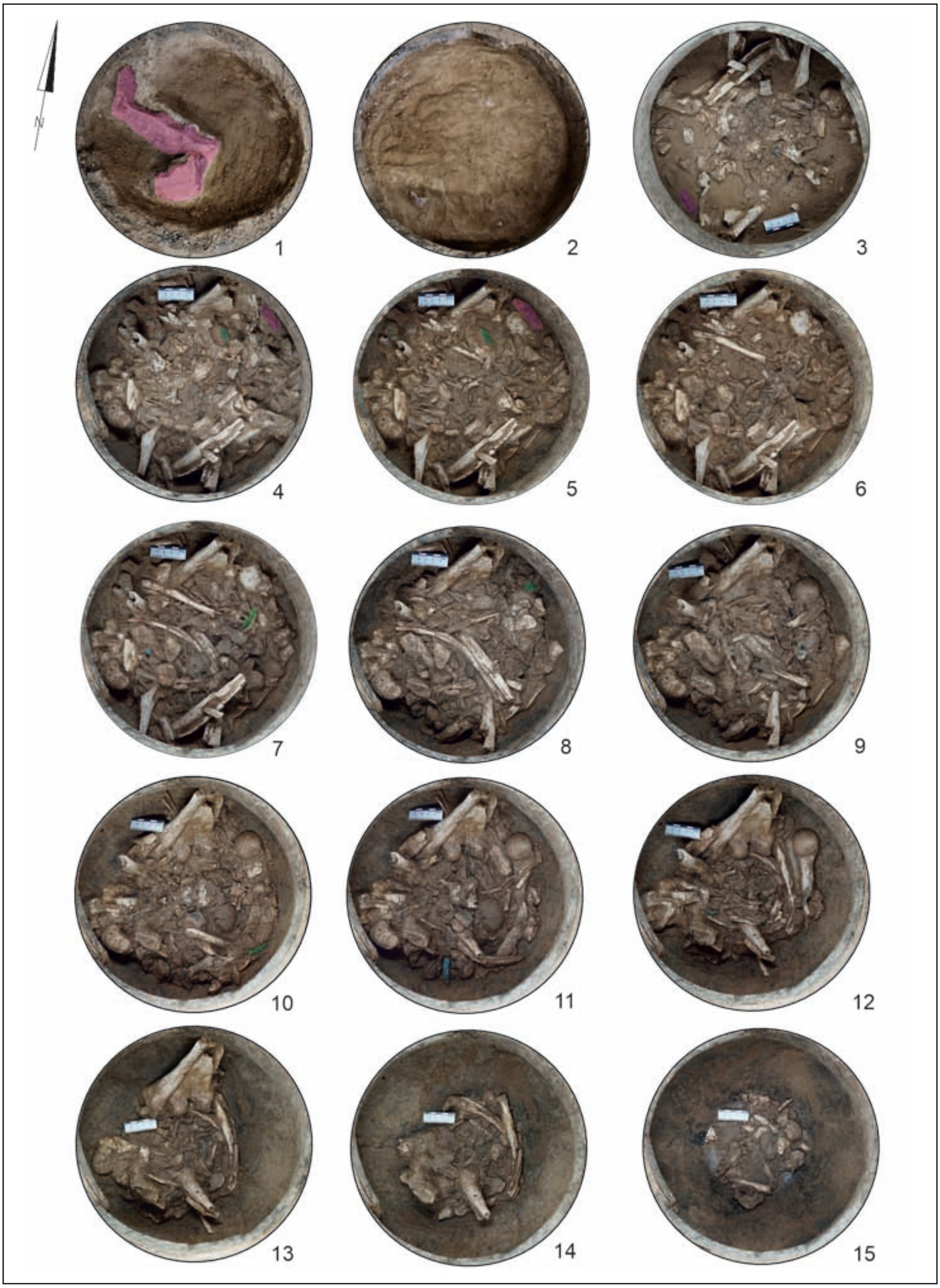

Fig. 5. Assemblage of 15 documentation layers of the micro-excavations of the urn from Markranstädt-129, including sherds of the covering bowl (violet) and other pottery fragments (blue and green)

Osteological analysis – general remarks

The osteological assemblage consisted of 576 three-dimensional measurements of human bone and tooth fragments. The total mass of the cremated remains is 2216 g with no bone elements exceeding the expected count for a single individual. According to experimental studies, the average weight of combusted remains of a male individual ranges from 1842 g (Herrmann 1976, cited in Gonçalves 2011, 29) to 3379 g (Baas and Jantz 2004, Table 4), with a median of 2680 g (based on studies by Bass and Jantz 2004; Chirachariyavej *et al.* 2006; van Deest *et al.* 2011; Herrmann 1976; Malinowski and Porawski 1969; McKinley 1993; Warren and Maples 1997). Such heat-induced weight loss results from the dehydration and decomposition of organic bone components (Hiller *et al.* 2003, 5093 ff.). These comparative data suggest that in the case of the Markranstädt burial, the cremated remains were almost entirely deposited in the urn. However, the osteological identification and cataloguing of the skeletal elements show that the anatomical representation of the cremated remains differs slightly from that of a complete skeleton (Fig. 6). While this discrepancy likely has a primarily taphonomic origin, it is also possible that certain ritual choices influenced the selection and deposition of the cremated remains. Different sequences of burning various body regions on the pyre (Symes *et al.*, 2015, fig. 2.8-2.8), as well as the varied structural composition of bone tissue, may have led to incomplete calcination of some skeletal parts, reducing their preservation potential. For example, under optimal conditions, the ventral side of the distal femur at the knee typically undergoes

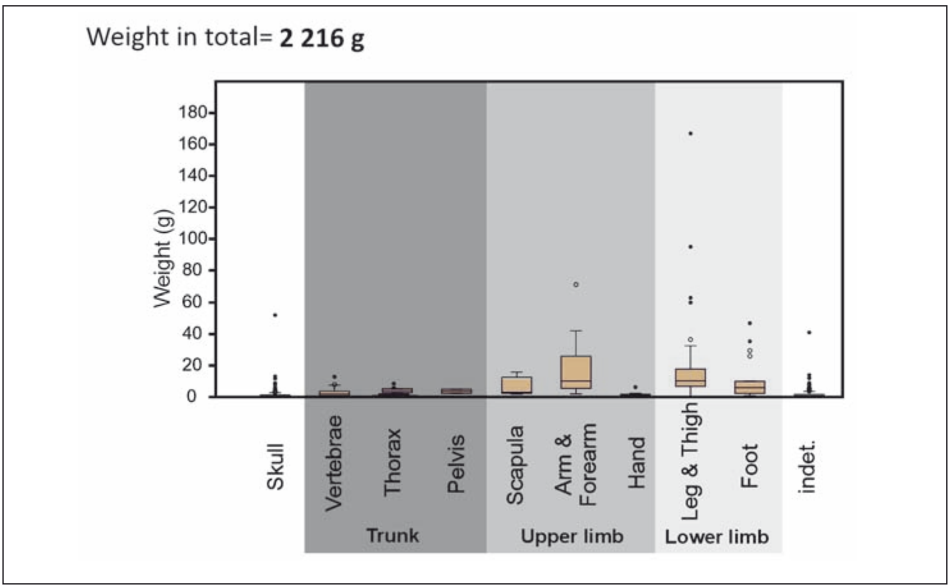

Fig. 6. Distribution of the cremated human remains from the burial at Markranstädt-129

Fig. 7. Selection of bones from the burial at Markranstädt-129:
left humerus (1), right and left radii (2), right and left foot bones (3), right fibula (4), distal epiphysis of the tibia with a marked *facies articularis malleoli medialis* (5), right and left patellae (6), right and left femora, dorsal view (7), left scapula (8), cervical vertebrae (9), thoracic vertebrae (11)

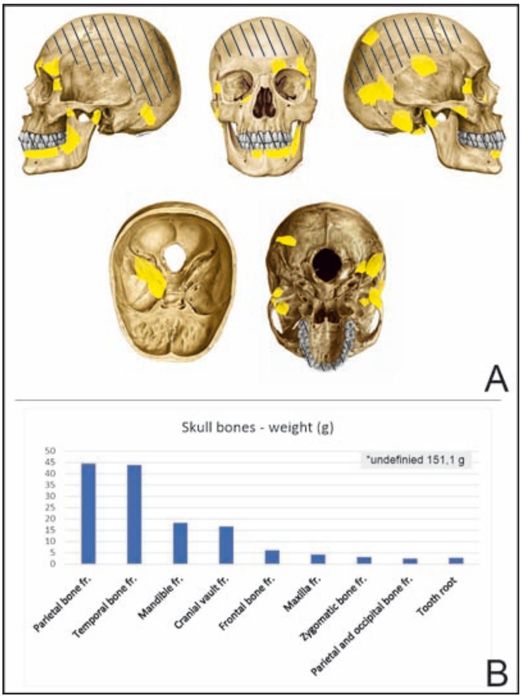

Fig. 8. Cranial element inventory from the burial at Markranstädt-129 (A); weight distribution of the identified cranial fragments (B)

burning in the early stages. In contrast, the proximal femur is affected later in the process (Symes *et al.* 2015, figs 2.8 and 2.9). If this pattern holds in our case, it might explain the absence of proximal femoral epiphyses in the remains from Markranstädt. However, the hypothesis of intentional selection of femoral epiphyses, if preserved, cannot be excluded entirely. Most bone fragments exhibit yellowish to white colouration, indicating – following the combustion stages defined by Herrmann *et al.* (1990, 259) and J. Wahl (1981, table 1) – temperatures exceeding 800°C. A few fragments show grey to bluish-grey colouration, which may point to lower temperatures around 550°C (Wahl 1981, table 1). These colour differences might reflect temperature fluctuations at different stages and locations during cremation, which aligns with the underrepresentation of certain skeletal parts.

The postcranial skeleton accounted for 1931.7 g. Of these, 1391 g belonged to the long bones of the upper and lower limbs, including the humerus (Fig. 7: 1), radius (Fig. 7: 2), ulna, fibula (Fig. 7: 4), tibia (Fig. 7: 5), and femur (Fig. 7: 7). Both patellae (kneecaps, Fig. 7: 6) were also identified, with a total weight of 29.1 g. Foot bones were particularly abundant (Fig. 7: 3), weighing 211.4 g in total. A further 37.1 g were attributed to hand bones, 30.1 g to both scapulae (Fig. 7: 8), and only 7.3 g to the pelvic bones. The trunk is represented by vertebrae weighing a total of 157.2 g (Fig. 7: 9, 10), and 94.5 g of rib fragments.

The skull fragments weighed 284.7 g (Fig. 8). Most fragments were identified as parts of the temporal bone (including both fossae mandibulares, the right mastoid process, and the right petrous part), and the parietal bone. Additionally, parts of the occipital bone, zygomatic bone with both frontal processes, and frontal bone (with the left supraorbital margin) were identified. Several mandibular fragments and one fragment of the maxilla were also present. Nineteen tooth root fragments were documented as well, including roots from five premolars or canines and four molars.

Several skeletal elements from the Markranstädt burial display heat-induced fractures. Most bone fragments exhibit taphonomic alterations consistent with exposure to high temperatures, such as warping (Fig. 7: 4) and thumbnail fractures (Fig. 7: 2). While some bones – such as vertebrae and metacarpal or metatarsal elements – were fully preserved, others, particularly long bones, were found fragmented. Notably, several lower limb bones show very similar fracture patterns (Fig. 7: 5, 7). At present, it remains unclear whether these fractures of the tibia and femur occurred naturally during carbonisation, without deliberate human intervention, or whether they resulted from intentional breakage during collection and placement in the urn. The presence of symmetrical thumbnail fractures could theoretically result from even burns on both sides of the body. However, slight differences in the maximum width of the tibiae (Table 2 in Suppl. data) and in the osteometric values of the tarsal bones (Table 3 in Suppl. data) – which are generally larger on the right side – suggest varying degrees of thermal shrinkage and, consequently, a non-uniform temperature distribution on the pyre.

Table 1. Sex estimation of the individual from the cremation burial MS-129, derived from osteometric measurements of the humerus and radius. Raw and corrected values (after Gonçalves 2011; Gonçalves *et al.* 2020) were evaluated using logistic regression equations for sex determination after Mall *et al.* (2001)

	MS-129 (mm)	**MS-129_burial 1 meassurements after correcture (based on Gonçalves 2011 and Gonçalves *et al.* 2020)**	**Logistic regression equations for sex estimation of unburned modern samples in western Germany (after Mall *et al.* 2001) value D < 0.30 suggest female; value D > 0.30 suggest male**	**MS-129**
Humeral head vertical diameter (HHVD)	44	4.84	D = 0,196 maximum lengt (cm) + 1.962 head diameter (cm) + 1.160 epicondylar width (cm) - 22.608	0.748
Humerus epicondylar width	56	6.16		
Humerus maximal lenght	306	34.262		
Radius distal width	31	3.41	D = 0,484 maximum length (cm) + 4.731 head diameter (cm) + 0.236 distal width (cm) - 21.680	2.431
Radial head dorso-ventral diameter	20	2.2		
Radius maximal lenght	238	26.649		

Table 2. Sex estimation of the individual from the cremation burial MS-129, based on comparative osteo-metric data of selected bones in relation to modern reference populations (after Gonçalves *et al.* 2011; Gonçalves *et al.* 2013) and ancient samples (after Cavazzutti *et al.* 2019)

	Mean rate of dimensional change of calcinated bones (Gonçalves 2011)	**MS-129_ raw data (mm)**		**Sexual differences on calcined bones of modern samples from Portugal (after Gonçalves 2011)**		**Logistic regression equations for sex estimation (after Gonçalves *et al.* 2013). positive values suggest males**		**Cut-of points for osteometric sex estimation based on calcinated bones of ancient Italian populations (after Cavazzutti *et al.* 2019)**
		R	L	Male	Female			
Humeral head transverse diameter (HHTD)	13.45%		40	39.16	33.76	-32.753 + 0.891 * HTTD	2.89	
Humeral head vertical diameter (HHVD)	11.86%		44	43.51	37.74	-26.919 + 0.661 * HHVD	2.17	37.88
Humeral epicondycar breadth (HEB)	9.67%		56	58.32	36.47			
Talus: maximum length A-B (TML)	11.38%	51	50	50.97	45.57	-32.849 + 0.683 * TML	1.94	46.87
Talus: trochlea length C-D (TTL)	14.70%	30	30	31.48	27.71			28.92
Calcaneus maximum length (CML)	11.78%	79		76.92	67.71	-39.628 + 0.549 * CML	3.74	
Calcaneus load arm length (CLAL)	11.95%	47		47.41	40.47			
Calcaneus load arm width (CLAW)	15.39%	38		38.80	34.19			
Cuboid maximum lenght (CL)	15.64%	40	38	33.66	30.24			
Cuboid maximum breadth (CB)	19.23%	30	32	25.23	22.30			
Cuboid maximum heigh (CH)	14.92%	24	22	21.52	21.21			
Navicular maximum lenght (NL)	17.41%		17	18.67	X			13.46
Medial cuneiform lengh (MCL)	15.50%	31		23.23	19.80			
Medial cuneiform lengh heigh (MCH)	13.57%	35	33	29.69	25.36			
Radial head dorso- ventral diameter	no data	20	20	X	X			18.32

Table 3. Estimated living stature of the cremated individual from MS-129, based on corrected long-bone lengths (after Gonçalves 2011; Gonçalves *et al*. 2020). Calculations follow Trotter (1970) and Rösing (1977) equations

	Maximal lenght	**Mean rate of dimensional change of caltinated bones (based on Gonçalves 2011; Gonçalves *et al.* 2020)**	**Maximal lenght after correcture (based on Gonçalves 2011; Gonçalves *et al.* 2020)**	**Equations used to estimate stature (in cm) from long bone lengths (after Trotter 1970)**	**Estimated living stature**	**Estimated living stature (Rösing method)**
Humerus maximal lenght	306 mm	11.97%	34.262 cm	3.08 * Hum + 70.45 ± 4.05	175.97 cm ± 4.05	
Radius maximal lenght	238 mm	11.97%	26.649 cm	3.78 * Rad + 79.01 ±4.32	179.74 cm ± 4.32	
Humeral head transverse diameter	40 mm	10.00%	4.4 cm			*ca* 167.5 cm
Radial head dorso- ventral diameter	20 mm	10.00%	2.2 cm			*ca* 175.5 cm

Table 4. Reconstructed sequence of bone deposition within the urn from the Markranstädt burial (MS-129), indicating intentional arrangement of skeletal elements during interment

Sequence of bone deposition in the urn	
1 – bottom of the vessel	Right patella
2	Right femur and left tibia *placed vertically*
3	Left arm (ulna → radius → humerus) *placed horizontally*
4	Left tibia and right femur *placed vertically*
5	Right humerus
6	Left patella
7	Scapular fragments *centrally placed*
8	Ribs and lumbar vertebrae
9	Foot and hand bones
10	Right and left fibulae and right ulna *placed horizontally*
11	Right radius *placed horizontally*
12	Skull bones and cervical vertebrae

Osteological analysis – anthropological Assessment of Age, Sex, and Stature

The study of skull sutures is a widely used method for estimating the age of unburned skeletons. Burned bones may lead to some misinterpretations due to the heat, which often causes ossified sutures to break apart, thereby giving the impression of belonging to a younger individual (Holck 2008, 64; fig. 8). Fortunately, this misjudgement can be verified by analysing fractal edges and surfaces. In this case, the biological age, based on the degree of cranial suture closure, can be estimated at 30-40 years old (*Adultus/Maturus*) (Holck 2008, 63-65; Piontek 1996, 150-152; Fig. 9).

In human skeletal analysis, specific morphological traits and bone measurements are commonly used to estimate biological sex (in adults) and living stature, provided that fragmentation and the absence of key skeletal elements do not prevent such analyses. As already mentioned, during cremation, bones undergo weight loss and shrinkage. Heat-induced dimensional changes have been the focus of numerous experimental studies (*e.g.*, Dokládal 1970; Bradtmiller and Buikstra 1984; Buikstra and Swegle 1989; Hummel and Schutkowski 1986b; Piontek 2007). The degree of shrinkage observed in these experiments varies significantly with factors such as combustion temperature, bone mineral con-

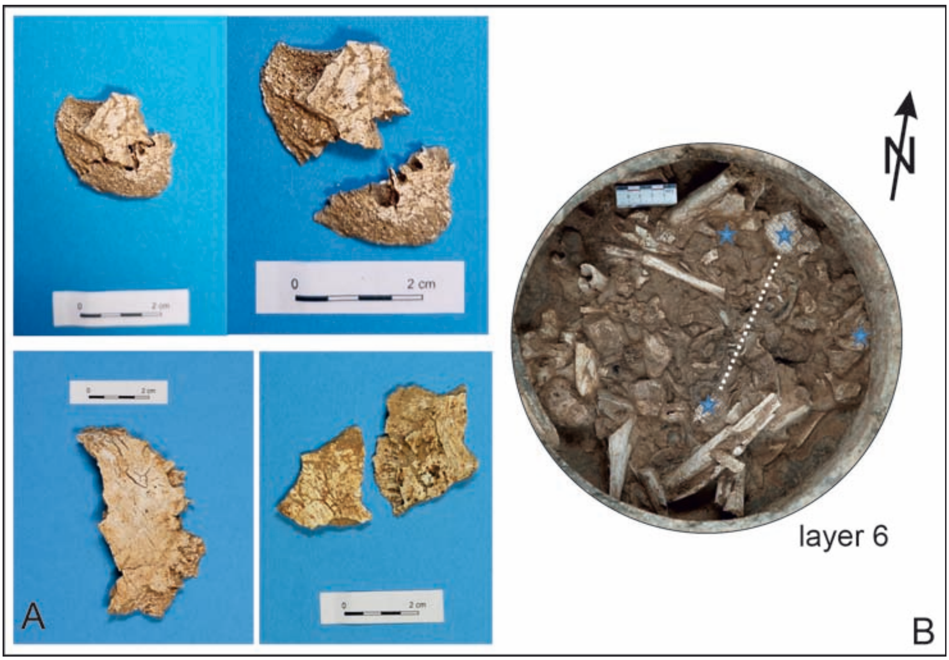

Fig. 9. Fragments of the parietal bone (lower left), and the temporal and occipital bones with an incompletely ossified lambdoid suture (A); position of the latter within the urn (B)

tent, differences between compact and spongy bone, and collagen fibril orientation (Gonçalves 2011 and references therein). Generally, bones heated up to 800°C exhibit relatively moderate shrinkage, while temperatures between 1000 and 1200°C may lead to shrinkage rates of up to 17%, depending on the duration of combustion and the specific bone type (Gonçalves 2011). Despite the unpredictability of dimensional changes in calcined bones, the application of osteometric methods to assess sexual dimorphism remains possible – albeit with certain limitations.

In the case of the individual from Markranstädt, no clear sex-specific morphological traits were preserved. However, the available osteometric data from the humerus and radius (Table 1), along with additional measurements (Table 2), strongly suggest that the individual is male. Furthermore, the estimated living stature of the possibly male individual from Markranstädt – reconstructed using the left humerus and left radius, with appropriate corrections for thermal shrinkage – ranges between 175.9 and 179.7 cm (±4 cm), based on Trotter's equations (1970), or between 167.5 and 175.5 cm according to the Rösing method (1977).

No pathological changes were observed in the osteological material. The pronounced articular surface of the distal tibia, which articulates with the medial surface of the talus, is common in prehistoric societies and is indicative of frequent squatting (Fig. 7: 5).

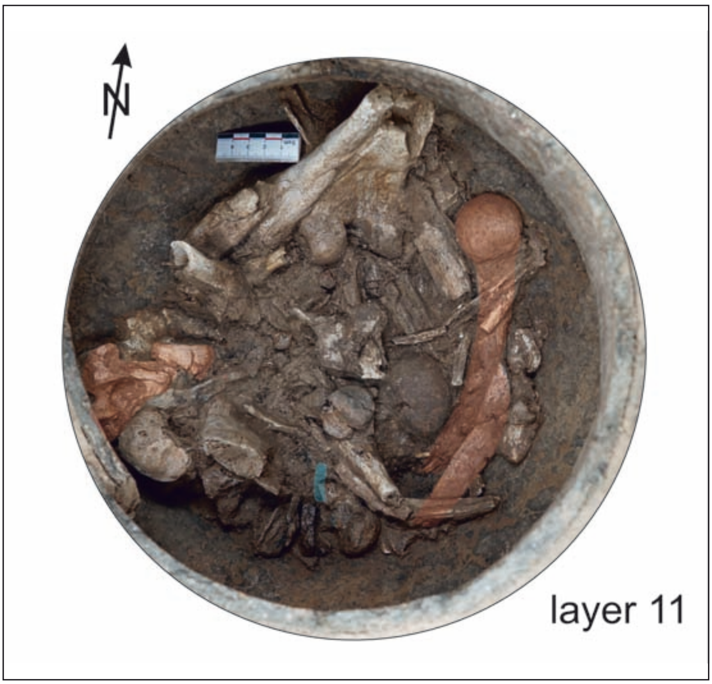

Fig. 10. Markranstädt-129: Position of the humerus (red) within the urn (orthogonal view)

Taphonomic and spatial observations on the deposition of cremated human remains within the urn

Despite the burial's complex taphonomy, several observations regarding the arrangement of bones within the urn can be made. Apart from the concentration of cranial bones and cervical vertebrae in the upper part of the urn, the bones are not anatomically grouped (Table 4).

However, some general patterns are discernible: long bones, particularly those of the lower limbs, tend to be oriented vertically, whereas upper limb bones are predominantly arranged horizontally. Notably, the upper limbs appear to follow a specific pattern (Figs 10 and 11), in which the proximal epiphysis are positioned opposite their respective distal joint ends.

Furthermore, the left and right bones of each pair appear to be in parallel alignment. Particularly striking is the vertical placement of the lower limb diaphysis at the base of the urn, with the left and right femora and tibiae arranged in an antithetical pattern (Figs 12 and 13).

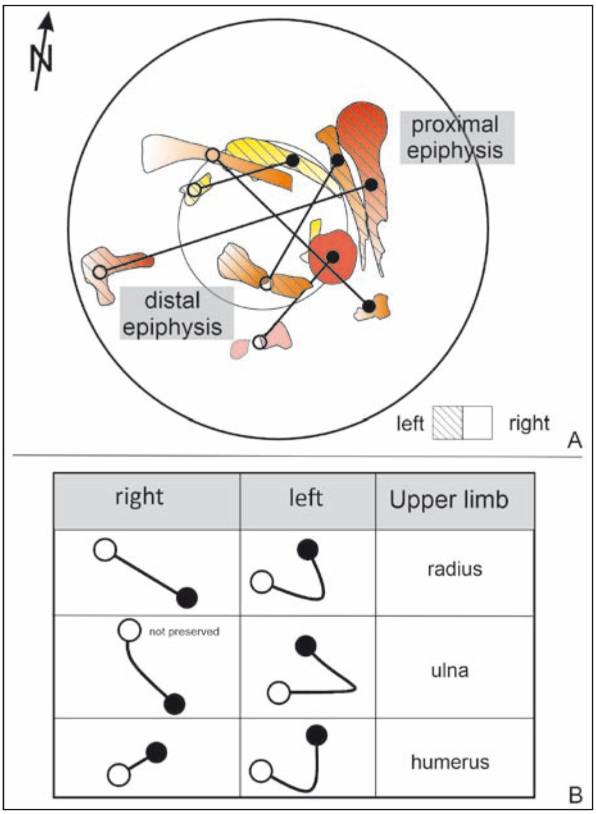

Fig. 11. Markranstädt-129: Arrangement of the upper limb bones within the urn (orthogonal view)

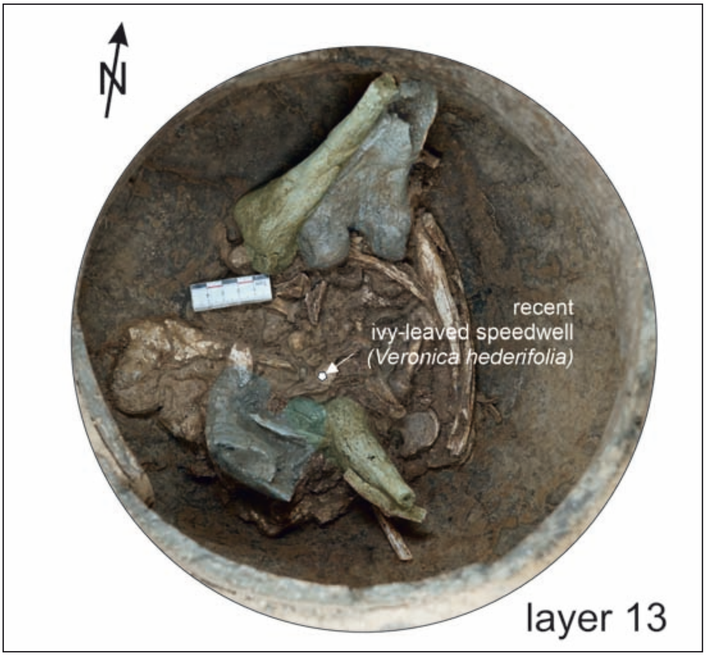

Fig. 12. Markranstädt-129: Position of the femora (orange) and tibiae (yellow) within the urn (orthogonal view)

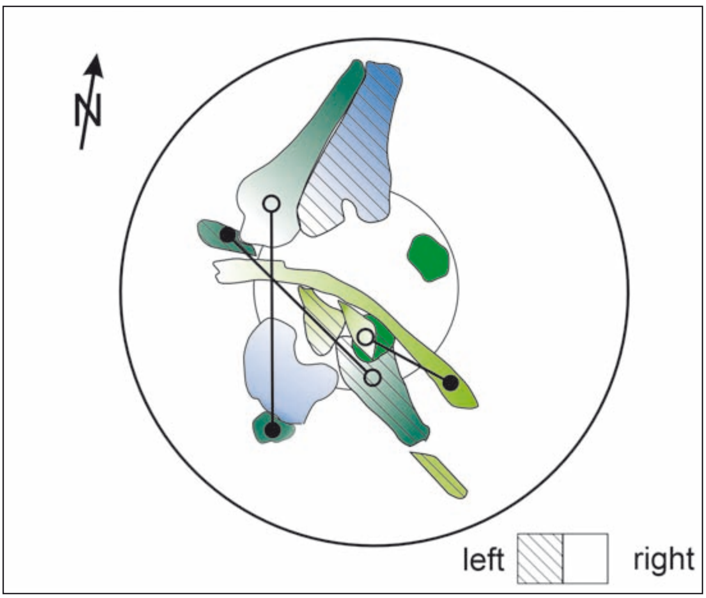

Fig. 13. Markranstädt-129: Arrangement of the lower limb bones within the urn (orthogonal view)

DISCUSSION

The reconstruction of the burial rite based on archaeological sources is a very vague and often misleading challenge. In our case, even the exact dating and cultural attribution of the grave from Markranstädt is not straightforward. It also remains unclear why the grave stands out as a singular feature. Comparable singular graves are known from northwestern Saxony – for example, from the archaeological site in Großlehna, approximately 2 km west of Markranstädt – but they are not a common type of funerary site. The isolated location of the analysed grave may be a result of the current state of research. The grave may be located in a peripheral zone of an as-yet undiscovered Late Bronze Age-Early Iron Age cemetery. The stone arrangement around the urn might reflect an unpreserved construction (barrow?) and may explain its distant localisation.

Another remarkable aspect is the low degree of bone fragmentation observed in the cremated remains. The large size of many bones is generally unusual in Late Bronze Age cremation burials. It is comparable to just a few burials from Late Bronze cemeteries, such as Großlehna in northwestern Saxony (Grave 22), Müllrose in eastern Brandenburg (Tiedke and Storch 2019/2020, Grave 590: 74-79) or Janowice 44 in Lesser Poland (Korczyńska *et al.* 2018, Grave 35). On the other hand, from Ha C/D onwards, a generally significantly low fragmentation of cremated remains can be observed – a trend demonstrated both in the Early Iron Age Pomeranian Culture (*e.g.*, Drozd-Lipińska 2022; Henneberg 1974) and within the Jastorf Culture (Wolska 2021). Also, lower fragmentation appears more frequently in Saxony at the beginning of the Early Iron Age (Schmalfuß *et al.*, in preparation). So, although the urn still resembles the Late Bronze Age pottery style, the degree of fragmentation of the cremated remains in the burial from Markranstädt might already reflect Early Iron Age cremation practices. This could suggest an anachronism in the vessels used (which style would be older) and in the cremation rites, potentially dating the grave to the 7th and 6th century BCE (Ha C).

However, we should also consider the possibility that the Late Bronze Age chronology of the grave is accurate. In such a case, low bone fragmentation might reflect the diversification of cremation traditions within smaller geographical regions (or archaeological cultural groups), as noted in Late Iron Age Southeastern Norway (Holck 2008, 106). This burial type could be interpreted as a variation of the so-called ‘special burials’ (German: ‘Sonderbestattungen’; Veit 2013, with further references). In Central Germany, non-normative burials are typically associated with inhumation remains in settlement pits (German: ‘zerrupftete Bestattungen’; Balfanz and Jarecki 2004) and have often been negatively interpreted, particularly within the culture-historical framework, as expressions of ritual, social, or violent contexts. However, this does not appear to be the case for the burial from Markranstädt, as the deceased individual, at least from today’s perspective, seems to have been treated with dignified respect. This might suggest that the transitional ritual in the sense of A. van Gennep (1909), which was intended to guide the individual to the ancestral realm, was carried out with care (see below for further discussion). It is important to acknowledge, however, that applying contemporary understandings of 'respect' and 'care' to prehistoric ritual contexts is methodologically problematic and epistemologically fraught. Archaeological interpretation inevitably involves projecting present-day cultural values and emotions onto past societies, risking anachronism, and must therefore be approached with caution. For this reason, the indications presented herein regarding funerary rites, or rather, funeral customs, should be understood as an interpretative heuristic grounded in the available evidence and hypotheses rather than as a specific direct correlation to modern emotional attitudes.

Experimental studies have shown that, following the collapse of the pyre during ongoing combustion, the burnt skeleton generally retains its original anatomical position, despite the typical shrinkage of muscles, tendons, and ligaments and the resulting 'pugilistic posture' – the position in which the body, after exposure to heat, adopts a fist-clenched, arms-flexed stance (McKinley 2015; Piontek 1976; Symes *et al.* 2015). In the postliminal phase, this allows for the collection of bones from the pyre in an intentional order and their placement in a deliberate, structured arrangement in the urn, as determined in Markranstädt, reflecting both ritual intentionality and practical considerations. According to the description in the Iliad (XXIII, 232-241), the funeral pyre on which Patroclus' body was cremated was extinguished with wine the following day, after which the remains of the hero of the battle with the Trojans were collected and placed into an urn. Experimental studies on the cremation process demonstrate that the funeral pyre remains hot for several hours (Leinweber 2002, 168; Wahl 1981, 275), and pouring liquid onto it not only lowers the temperature but also facilitates the differentiation of burned bones from ashes (Pany-Kucera *et al.* 2013, 209). The extremely low number of charcoal fragments in the urn and absence of an ash layer on the bone surfaces suggest that the combusted remains may have been cleaned – possibly even washed – prior to deposition in the urn. Similar observations have been reported from many other Late Bronze Age cemeteries (*cf.*, Hałuszko *et al.* 2015; Korczyńska *et al.* 2018; Wolska *et al.* 2024). Additionally, the low degree of fragmentation observed in Markranstädt indicates that the pyre was at least partially cooled prior to being doused with liquid (*cf.*, Gramsch 2010, 152; Wahl 1981, 276).

In the Markranstädt burial, skull bones and cervical vertebrae appear to have been deposited in the upper parts of the burial, which may reflect the sequence of post-cremation bone sorting. The central placement of scapular fragments could reflect their symbolic role. The conspicuous positioning of skull bones in Late Bronze Age cemeteries across Central Europe has been repeatedly documented through modern, stratified anthropological studies. For instance, in late Lusatian Culture cemeteries in Brandenburg (*e.g.*, Cottbus Alvensleben-Kaserne; Gramsch and Großkopf 2005), Greater Poland (*e.g.*, Wtórek; Hałuszko *et al.* 2022), Silesia (*e.g.*, Rolantowice; Hałuszko *et al.* 2015), and the Świętokrzyskie Voivodeship (*e.g.*, Podlesie 5; Jaskulska 2018), skull fragments are predominantly found in the upper layers of urn deposits. Similarly, in the non-urn cremation grave from the biritual Lusatian Culture cemetery at Opatów, Lesser Poland, cremated skull fragments of a child in the *Infans I* age group were placed in the northern part of the burial pit, with all remains deposited in anatomical order (Szczepanek and Jarosz 2013, 38, 47). The deposition of skull bones as the final element is generally interpreted as evidence of a deliberate ritual act, suggesting an 'anthropomorphisation' of the urn and the symbolic 'reintegration' of the deceased into society (Gramsch 2010).

In the urn from Markranstädt, certain bones show bilateral symmetry in their placement, including both femora, tibiae, and fibulae. Long bones of the lower limbs tended to be placed vertically, whereas upper limb bones were arranged horizontally, perhaps due to their morphology. On the contrary, the spatial division of proximal and distal epiphyses of the upper limbs might be interpreted as part of a ritualised deposition sequence beyond the anthropological order. Similar observations were made from a few burials from Cottbus Alvensleben-Kaserne. At this cemetery, a particular arrangement of bones could occasionally be observed, such as long bones laid parallel to one another or joint heads aligned with opposite sides of the urn or placed parallel to each other (Gramsch and Großkopf 2005, 85). Also, at the Early Iron Age cemeteries in Zapceń, Klukowo, and Lipnica in Pomerania, F. Rożnowski (1995) described several bone-deposition patterns, one of which illustrated the deposition of larger bones at the bottom of the urn.

Altogether, these observations suggest a deliberate and meaningful process of selecting and placing cremated remains, rather than random deposition. However, due to the scarcity of comparative material, it remains unclear whether this pattern represents an individual, isolated act or a recurring practice within a broader cultural or regional funerary tradition. Notably, the urn from Markranstädt displays strong stylistic affinities with the late Lusatian Culture of Middle Saxony. However, the absence of accompanying vessels is atypical for the burial customs of that period and region, which are generally characterised by more complex graves. Conversely, the presence of large stones aligns more closely with the funerary practices of western groups, such as the Saalemündung group in Saxony-Anhalt. Meanwhile, the size and arrangement of cremated bone deposits bear resemblance to customs commonly observed in numerous Early Iron Age cemeteries. Consequently, the Markranstädt grave appears to embody influences from multiple funeral traditions of the surrounding regions.

CONCLUSION

The cremation burial from Markranstädt provides a highly significant and complex case within the archaeological context of the Late Bronze Age and Early Iron Age in Northwestern Saxony. The stone arrangement, potentially indicating the presence of a former barrow or other grave constructions that have since eroded or been destroyed, together with the burial's spatial situation, raises questions about the broader context of the grave, which may in fact be part of a larger, yet undiscovered, cemetery. Based on osteological analysis, archaeological and taphonomic observations, several key aspects emerge that offer valuable insights into burial customs and the social context surrounding the deceased individual.

The biological age estimation of the deceased placed it between 30 and 40 years of age at the time of death, along with the reconstructed relatively high stature. The absence of pathological changes further supports the notion of a probably healthy person, though the distinctiveness of the burial may reflect a special status or role within the community.

One of the most striking features of this burial is the low degree of fragmentation in the cremated remains and their spatial arrangement in the urn. This trait sets the Markranstädt burial apart from most other Late Bronze Age graves, despite the typochronological assignment of the urn to the Late Bronze Age context. The relatively large size of the bone fragments is observed at many Early Iron Age cemeteries. This suggests that Grave 1 may represent a transitional funerary tradition in which cremated remains were deposited within an urn resembling late Lusatian Culture style, while the combusted remains themselves were already being treated in an Early Iron Age manner, though a highly structured and intentional process.

In that sense, the burial at Markranstädt provides significant evidence of the complexity of funerary practices during the transition from the Late Bronze Age to the Early Iron Age. It could illustrate the symbolic transformation of the deceased into an ancestor, as described by van Gennep's concept of *Les Rites de Passage* (1909). The deliberate selection and arrangement of bones, along with the broader stylistic context of the grave vessels, suggest that the burial of this possibly male individual from Markranstädt was part of a ritualised act aimed at ensuring a successful passage into the ancestral realm and further enhancing cohesion of the local community. In this regard, the present study contributes to a deeper understanding of at least one funerary practice in Northwestern Saxony in the Late Bronze Age / Early Iron Age. It highlights the region's cultural or group-specific diversity during this transitional period.

Acknowledgements

The author gratefully acknowledges Dr. Regina Smolnik and Dr. Harald Stäuble for granting access to the materials deposited at the Landesamt für Archäologie Sachsen. Sincere thanks are also extended to Sven Kretzschmar and Peter Rudolf for their work in preparing the block recovery and for their fruitful collaboration. Further gratitude is expressed to Dr. Christoph Herbig for the taxonomic identification of the archaeobotanical macroremains and to Dr. hab. Magdalena Moskal-del Hoyo for her assistance with the identification of the charcoal remains. Special thanks go to Dr. hab. Anita Szczepanek (Prof. PAS) for her help with the identification of the skeletal remains and for proofreading the manuscript. The author also thanks Dr. Kathrin Balfanz for granting access to the documentation of the urn burial from Großlehna. Finally, the author wishes to thank the anonymous reviewers for their valuable comments and constructive suggestions, which significantly improved this work.

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