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NEW DATA FOR RESEARCH ON THE EARLY BRONZE AGE IN NORTHERN POLAND (2350-1600 BC)

THE EARLY BRONZE AGE IN NORTHERN POLAND: A GENERAL VIEW

During the long period of 2350-1600 BC, the region of northern Poland[1] saw many important and vigorous cultural changes and set the stage for two different traditions of the Late Neolithic and Early Bronze Age (EBA) to meet together and interact. The cultural trajectories in these lands were changing dynamically and, in contrast to southern areas that were in the range of the Únětice culture (ÚC) and people belonging to the Mierzanowice and Strzyżów cultures, regional communities from the north were generally far from settling into long-term habitations, nor were they burying their kin in multi-generational cemeteries. The cultural landscape seen in the lowlands and lake districts of northern Poland was ephemeral, and highly prone to destabilisation, hybridisation and disintegration, which resulted in a complex nomenclature for archaeological materials from that period (cf. Bokiniec 1999, 65-68). The accuracy of the cultural homogeneity model has been questioned for the EBA in northern Poland (e. g. Bokiniec/Czebreszuk 1993; Bokiniec 1999; Czebreszuk 2001), and it is now widely accepted that the complex picture of this region is best explained through cultural polymorphism.

The beginnings of the Bronze Age have been investigated to greatly varying degrees across northern Poland, and the Kuyavia region is the most studied area[2]. Thanks to the scientific activity of Aleksander Kośko and the research team around him (*Ekspedycja Kujawska*), many field studies were undertaken in Kuyavia, and a variety of explanatory models have been presented. In this context, a model of cultural integration at the turn of the Late Neolithic and Early Bronze Age in northern Poland is especially attractive (Kośko 1979; 1991; Cofta-Broniewska/Kośko 1982). Following this model, the socio-economic changes in this region are held to have stemmed from a proto-Únětican background, with an admixture of cultural patterns from the Lower Oder group of the Corded Ware culture and the Bell Beaker culture. By the later EBA, the role of integrating local communities was taken over by the Iwno culture, and the spread and uptake of foreign EBA patterns in other parts of northern Poland have been called »Iwienisation« (Kośko 1979). In subsequent monographies on the Kuyavia region (Czebreszuk 1996; 2001), the primary emphasis has been on the Bell Beaker migrants from the north-west, and groups associated with the *Riesenbecher* pottery (Czebreszuk 1996; 2001; Makarowicz 1998).

In the Lower Oder and Pomerania, studies of the EBA are not very advanced (cf. Bukowski 1998; Czebreszuk 2001). Research is limited to areas along the Lower Oder, and mainly related to the Western Baltic centre of production of flint daggers (Libera 2001; Czebreszuk/Kozłowska-Skoczka 2008), and studies of the Corded Ware culture in the region. Cultural perturbations in this area during the EBA, as in the Kuyavia region, are seen through the absorption of two foreign milieus, the Bell Beaker and Únětican (Czebreszuk 2001; Matuszewska 2011). There is currently no systematic work on the beginnings of the Bronze Age in the Lower Vistula[3]. It is only in recent years that excavations have been run on several settlement and burial

sites from Eastern Pomerania and Chełmno land (Kałdus cemetery 2015; Kurzyk 2013; Kurzyk/Ostasz 2015; Wadyl/Kurzyk 2018).

The state of research on the beginnings of the Bronze Age in north-eastern Poland changed positively in the 2010s (e. g. Manasterski 2009; 2010; 2016; Wawrusiewicz/Januszek/Manasterski 2015; Sobieraj 2019; see also Dąbrowski 1997). It is now believed that the area stretching from Warmia and the Masurian Lake District to Podlachia hosted various traditions of the Late Neolithic, Subneolithic and Early Bronze Age that were being amalgamated. There too, the key role of the Bell Beaker culture is emphasised, as exemplified by recent discoveries near Supraśl in Podlachia (Wawrusiewicz/Januszek/Manasterski 2015; Manasterski et al. 2020). The extensive field works at a fortified settlement of the Kościan group in Bruszczewo in Greater Poland must also be acknowledged, which have contributed to refining the role of the Únětice culture in the overall cultural landscape of the Polish Lowlands during the EBA (Czebreszuk/Müller 2004; 2015; Müller/Czebreszuk/Kneisel 2010; Czebreszuk et al. 2015).

This overview should also reference the typological and cartographic surveys on metal artefacts, which were published by Polish academics as part of the *Prähistorische Bronzefunde* series (Gedl 1980; 2004; Blajer 1984; Szpunar 1987). These, along with other publications, have helped to systematise a large corpus of metal objects through the concept of the hoard horizon and to gain better insight into local bronze production and metal consumption in the region of modern Poland during the EBA (Blajer 1990). The results of archaeometallurgical studies are becoming increasingly integral to archaeological interpretations (e. g. Rassmann 2010b; Silska 2012b; Bugaj et al. 2017; Kowalski/Garbacz-Klempka/Dobrzański 2017; Gan 2020; see also Sarnowska 1969; 1975; Dąbrowski 2000), although we unfortunately see an ongoing deadlock in Polish archaeometallurgy, which still lacks lead isotope data in metal provenance studies. In this context, recent research on the beginnings of the Bronze Age in Warmia and in the Masurian Lake District (Sobieraj 2019) is particularly noteworthy, which filled this gap with the first lead isotope data for the earliest metal artefacts from the Bronze Age in northern Poland (Stos-Gale 2019).

In addition to academic research and professional excavations, increasing numbers of archaeological objects have been found in Poland as accidental discoveries or from amateur surveys, which is particularly due to the increasing activity of metal detecting groups. Many such discoveries are stray finds that were found with little or no associated material or structures, but their limited scientific potential can still be used to boost knowledge on the beginnings of the Bronze Age in northern Poland, especially in the areas outside the immediate range of the so-called Early Bronze Age civilisation. In this paper, we therefore present archival archaeological material and some recent discoveries of stray finds from north-central Poland to determine their chemistry and technology and to relate them to different models of the inflow and consumption of Early Bronze Age patterns in the region. Although the main corpus of this study are stray finds, such an approach makes it possible to observe through the analysed objects how local post-Neolithic communities from northern Poland were being integrated with the Bell Beaker and Únětican milieu. Most of the artefacts investigated in this project come from the site of Lachmirowice in the Kuyavia region (**fig. 1**), including ceramic vessels and a stone tool identified as an arrow shaft straightener. The remaining analysed objects are two clay tuyeres excavated from Chełmno land, and three stray finds of bronze daggers from the region of Greater Poland and Mazovia. The results of the archaeometallurgical analyses of the metal objects provide a framework to discuss metal trading networks and the wider stylistic and technological trajectories in the region. An examination of clay tuyeres addresses the question of local bronzesmithing in the satellite groups of the ÚC from northern Poland and touches upon the issues of itinerant metalworkers and metalworking know-how transfer. A metal-oriented perspective helps better understand the »Iwienisation« and metallisation process at the margins of the metal-using societies of the earlier Bronze Age in northern Poland.

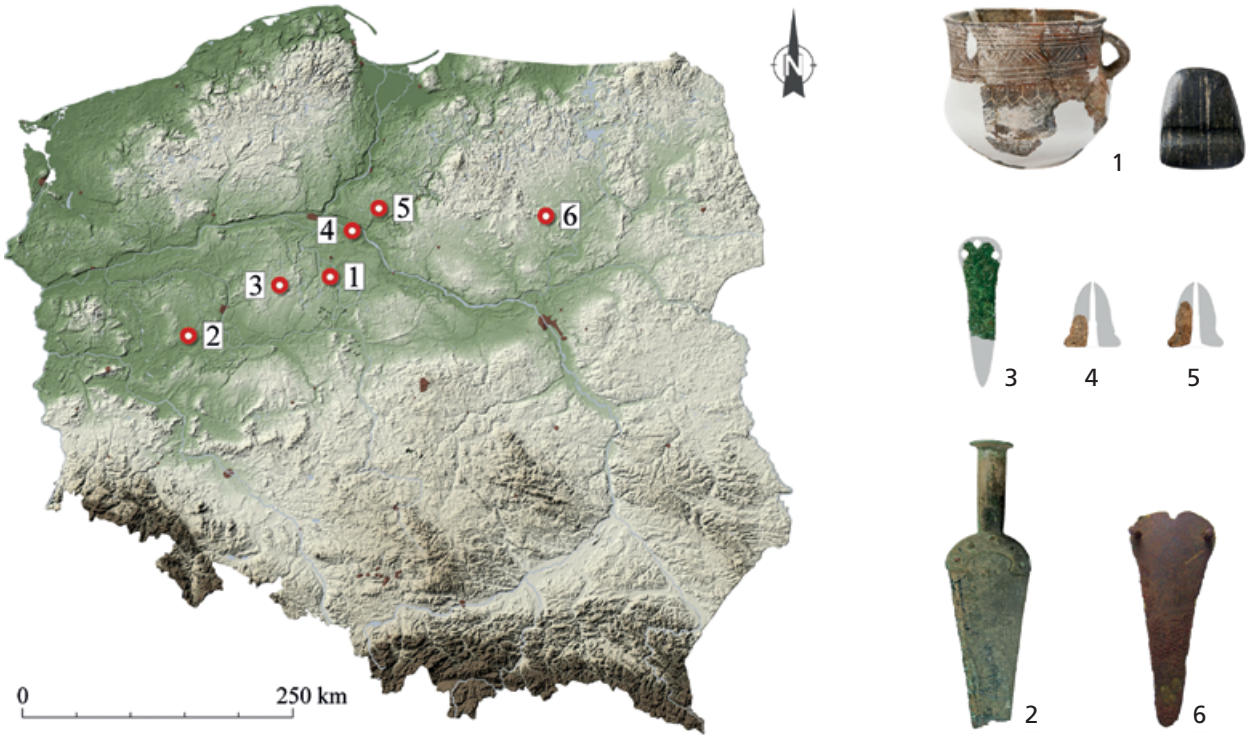

Fig. 1 Map of Poland showing the location of the artefacts analysed in this study: **1** Lachmirowice (woj. kujawsko-pomorskie). – **2** Łęki Wielkie (woj. wielkopolskie). – **3** Szczytniki Duchowne (woj. wielkopolskie). – **4** Toruń-Gręboc in (woj. kujawsko-pomorskie). – **5** Zieleń (woj. kujawsko-pomorskie). – **6** Zwierzyniec (woj. mazowieckie). – (Map Ł. Kowalski; map background AridOcean/Shutterstock.com).

CONTEXT OF DISCOVERY

The Artefacts from Lachmirowice (woj. kujawsko-pomorskie / PL)

A recent archival survey in the archaeological collection of the District Museum in Toruń produced numerous materials that were excavated by Bonifacy Zielonka in the early 1950s at the multicultural site of Lachmirowice in central Poland, approximately 20 km south of Inowrocław. The archival record includes settlement and funerary artefacts that signify various stages of the (pre-)historic habitus at the site, spanning from the Neolithic to the Early Middle Ages (Zielonka 1951a; 1951b; 1951c; 1951d; 1953). A collection of ceramic vessels was distinguished among the artefacts assigned to the (pre-)Roman period, which can be linked to the Bell Beaker culture. Regrettably, there are no reference numbers on the potsherds to confirm their exact deposition, nor was there detailed information on a catalogue card or an entry in the inventory book of the Museum in Toruń. The only information referring to the »(pre-)Roman collection« – including the Beaker pottery – is two brief notes made by Zielonka: »trench II, settlement I, pit« and »potsherds with smoothened and rough surface; dark, two-conical pot; late La Tène period, trench II, settlement I, 1951 (August-November)«. These two archival references have created some confusion by not explicitly mentioning the Bronze Age ceramics, they do not however exclude the possibility that Beaker pots were recovered from a secondary context. It seems reasonable to expect that the vessels were originally placed in a burial(s) pit which was later disturbed during the (pre-)Roman period at the site, losing their original deposition context as a result. The archival finds also included an object identified as an arrow shaft straightener, which can be added as Bell Beaker or Beaker affiliated. The object was re-made from a stone axe and collected from settlement 2 in Lachmirowice, with no associated material or structures.

The Clay Tuyere from Toruń-Grębocin (woj. kujawsko-pomorskie / PL)

During archaeological excavations between 1990 and 1991 run by the Nicolaus Copernicus University in Toruń at site 243 in Toruń-Grębocin, two separate domestic clusters (I and II) were identified that can be linked to the Iwno culture. The fieldwork covered a total area of ca. 500 m^2, and yielded more than 8000 potsherds and 1200 flint artefacts, defining the site of Toruń-Grębocin as a central settlement of the Iwno people from the region (Bokiniec 1993a). A fragment of a tuyere made of clay was found among the artefacts associated with cluster I, accompanied by ceramic material that signifies the classic phase of the Iwno culture in Chełmno land (Bokiniec 1995, 141-142).

The Clay Tuyere from Zieleń (woj. kujawsko-pomorskie / PL)

In 2012, archaeological excavations run by the Nicolaus Copernicus University in Toruń at site 38 in Zieleń near Wąbrzeźno uncovered the relics of a small, rectangular pole construction that can be linked to the infrastructure of the Iwno culture household (Bokiniec 1993b). One of the most interesting archaeological finds from the site is a fragment of a clay tuyere. The object was accompanied by a polishing stone and a vast collection of flint and ceramic material that belong to the later stages of the Iwno culture habitus in Chełmno land (Bokiniec 1993b, 65; 1995, 141).

The Dagger from Zwierzyniec (woj. mazowieckie / PL)

In 2013, an archaeological survey was run by the Mazovian Historical Association *Eksploratorzy.pl* at the redoubt of the January Uprising of 1863 near the village of Drążdzewo in east-central Poland, ca. 30 km west of Ostrołęka (Wyrostkiewicz 2014). Over 11 acres of the redoubt were examined with metal detectors, yielding a vast collection of military and other metal objects that date to the modern era. The most eloquent archaeological find from the survey was a bronze dagger, which was found in the foothills of Płaska Góra[4] near the village of Zwierzyniec, Maków dist. (Miecznikowski 2017; Borkowski / Miecznikowski 2018). The metal object was unearthed from the topsoil with no associated material or structures. No further archaeological data was collected during a re-investigation of the place of discovery and its vicinity.

The Dagger from Łęki Wielkie (woj. wielkopolskie / PL)

This artefact was discovered accidentally in 2018 during farming activities in the village of Łęki Wielkie, ca. 3 km south of the famous archaeological site at Łęki Małe, where the Únětician »princely graves« associated with the Kościan group were found in the late 19th century. The dagger was unearthed from the topsoil with no associated material or structures.

The Dagger from Szczytniki Duchowne (woj. wielkopolskie / PL)

This artefact was found in the early 2000s during amateur metal detecting near the village of Szczytniki Duchowne in central Poland, ca. 6 km east of Gniezno. According to the anonymous finder, the dagger

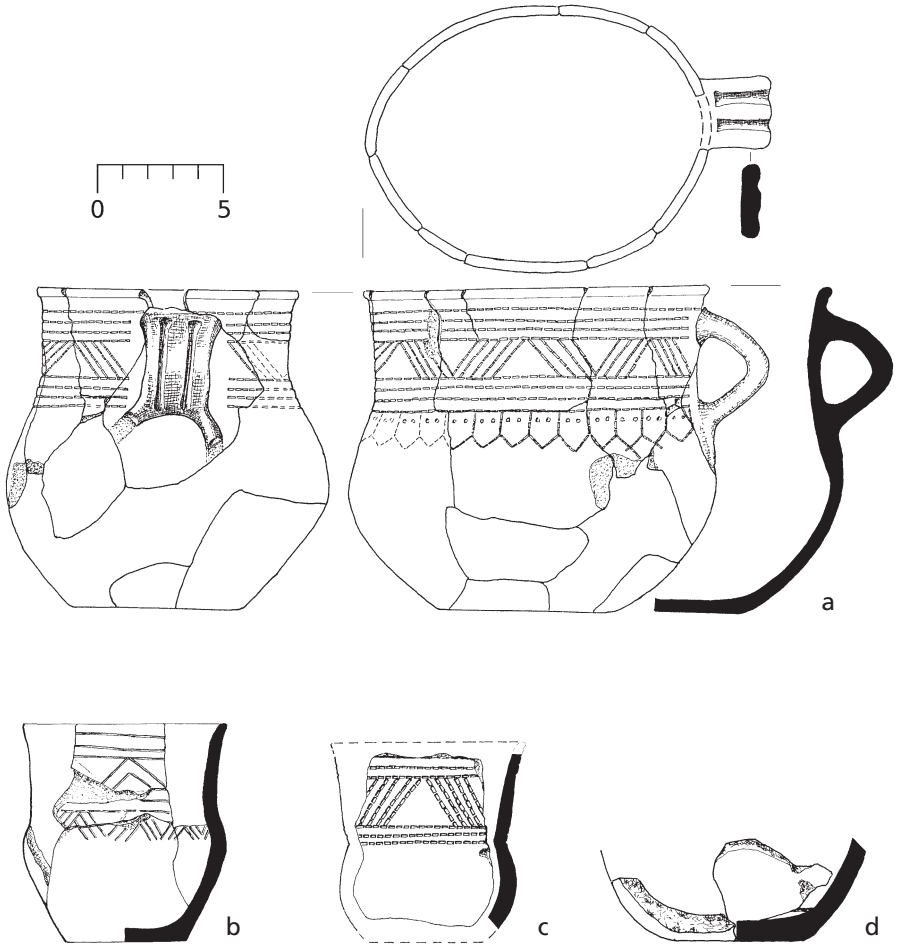

Fig. 2 The ceramic assemblage from Lachmirowice that can be added as Bell Beaker or Beaker affiliated. The vessels could have originally been placed in a burial which was later disturbed by human activity during the (pre-) Roman period at the site. – (Drawings B. Wawrzykowska; courtesy of the District Museum in Toruń). – Scale 1:3.

was unearthed from the topsoil and placed between stones that were perhaps the remains of a burial structure.

TYPOLOGICAL BACKGROUND

The Pottery

The assemblage[5] from Lachmirowice includes four ceramic containers: three have been restored to their full shape, and one fragment is the bottom from a fourth vessel of unknown type. The detailed morphology and metrics are presented for each vessel, and comments on the ceramic technology and decoration can be also found in this section.

(i) One-handled cup (**fig. 2, a**). The vessel is bipartite with a neck running gently outwards, while the belly is rounded and squat. The cup is provided with a small base that joins smoothly to the belly, and a strap handle is attached between the shoulder and slightly thickened lips. The cup is noticeable for having an oval rim, which resulted from secondary firing that can be connected to the (pre-)Roman residence at the site. The clay paste is tempered with a notable amount of white coarse and fine- and medium-grained mica, and also shows a small amount of fine sand that can be related to parent clay material. Metrics: total height 12.8 cm, belly height 8.0 cm, max. rim diameter (ø) 13.7 cm, belly ø 14.6 cm, bottom ø 6.8 cm, handle width 2.8 cm.

(ii) Beaker (**fig. 2, b**). The vessel is bipartite with a tall neck gently widening upwards, while the belly is slender and runs down at a sharp angle to a small base. The fabric cannot be successfully identified due to the full restoration of the vessel, but there are macroscopically visible and occasional medium-grained white coarse minerals on the ceramic body. Metrics: total height 8.7 cm, belly height 0.5 cm, rim ø 8.0 cm, belly ø 8.0 cm, bottom ø 4.8 cm.
(iii) Beaker (**fig. 2, c**). The vessel is bipartite with a tall neck gently widening upwards, while the belly is rounded and runs down to a broad and rounded base. The ceramic paste contains a considerable admixture of white and white-pink coarse minerals with fine, medium and large grain size. A small amount of fine sand and mica are also discernible on the ceramic body, which are perhaps related to parent clay material. Metrics: total height 7.8 cm, belly height 3.9 cm, rim ø 7.8 cm, belly ø 6.9 cm, bottom ø 4.4 cm.
(iv) Bottom fragment from a vessel of unknown type (**fig. 2, d**). Metrics: bottom ø 5.3 cm.
The pottery from Lachmirowice is consistent in terms of decoration style, which is based on horizontally organised zones with metope ornamentation located on the vessels' necks. In the upper and lower zones, multiple horizontal lines are incised, between which the middle zone is filled with rafters. In two vessels, the lower part of the main decorative motif is expanded with an added geometric element, which is multiplied on the shoulder: on the one-handled cup »A« this is a roof-shaped motif (**fig. 2, a**), and in the case of beaker »B« it is a sequence of repeating rafters (**fig. 2, b**). Vessels »A« and »C« are decorated with comb impressions and/or the knurling technique[6], while the motifs on beaker »B« were made by incisions. The one-handled cup »A« has the most elaborate ornamentation because together with the incisions, punctures and roulette impressions on the main body, the vessel is provided with a strap handle, which is decorated with two parallel grooves and a plastic moustache decoration protruding down the root of the handle of the cup. The remains of a white paste have been preserved inside the roulette impressions in the middle part of the cup.
The archaeological context and location of the discovery are good grounds to assign the assemblage from Lachmirowice to the Kruszki group which marks the starting point of the Bronze Age in northern Poland (Kośko 1979; 1982; 1991). The Kruszki group is characterised by the co-occurrence of settlement and burial materials that appear to have been derived from the Bell Beaker culture, the Lower Oder group of the Corded Ware culture (*Oderschnurkeramik*) and the proto-Únětice culture[7]. A clear concentration of Bell Beaker residences was identified by Kośko (1979, 141) in the vicinity of Lake Gopło in central Kuyavia, which at the time was controlled by the Kruszki group. The artefacts from Lachmirowice are well in line with this cultural configuration, both in formal and geopolitical terms.
The two beakers are bipartite vessels with a clearly marked shoulder (**fig. 2, b-c**), and their technology and ornamentation are typical of the transition period from the Neolithic to the Bronze Age in the South Baltic area (Czebreszuk 1996, 93-95 tab. 11; Matuszewska 2011, 100-103). In the Lower Oder, such vessels are usually dated to 2500/2300-2100/1900 BC, and assigned to the Corded Ware 3 group[8], which was an offshoot of the Single Grave culture with an admixture of Bell Beaker and proto-Úněticean elements (Matuszewska 2011, 108-113).
One-handled cups from funereal contexts are known as the accompanying ware (*Begleitkeramik*) and are commonplace in the Carpathian Basin and Danube region (Turek 2013). In Poland, Beaker cups are most frequently finds from Lesser Poland and Silesia (e. g. Wojciechowski 1972; Budziszewski/Włodarczak 2010). The cup from Lachmirowice stands out from the rest of the vessels in displaying zones with metope ornamentation, which is a widespread decorative motif in the Lower Oder (e. g. Siadło Górne [woj. zachodniopomorskie/PL]; Matuszewska 2011, pl. 29, 1) and in Kuyavia (e. g. Bożejowice near Żnin [woj. kujawsko-pomorskie/PL]; Kośko 1991, fig. 8, 1), but can also be traced to proto-Úněticean sites from Silesia (e. g. Marszowice near Wrocław [woj. dolnośląskie/PL]; Sarnowska 1975, 119 fig. 49i). On the whole, the cup from Lachmirowice has a very similar appearance to the pottery style that developed in Bohemia and Mora-

via, which can be evidenced by using white pottery inlay (cf. Všianský/Kolář/Petřík 2014; Kopec 2018), however, this connection is particularly clear through a plastic moustache (or tusk) decoration on the handle of cups (Turek 2002, 222-223 figs 1-2; 2013, 169-173; Turek/Dvořák/Peška, fig. 5). Jan Turek (2011, 54 fig. 3, and refs.) has plausibly suggested that such plastic decoration on the one-handled cups may be related to the male gender, as are the inverted Y-motifs that are usually distributed in even numbers of two or four. He also claims that male and female symbols are never combined on a single pot and that such gendered pottery could be used to highlight the differences between male and female burials, making it possible to argue that the assemblage (or at least the cup) from Lachmirowice was originally placed in a male grave. The Beaker cup from Lachmirowice can be dated to the PDZ 1 period (with a possible transition to PDZ 2) in the current chronology for Kuyavia, whose absolute dates fall between 2500/2450 and 2300/2250 BC (Czebreszuk 1996, 192).

The Tuyeres

These objects are badly damaged conical tuyeres made of clay with medium- and coarse-grained granite temper and mica, which is a typical recipe for the storage ware of the Iwno culture (cf. Kowalski 2014). A hypothetical reconstruction suggests that the tuyeres could have originally been approximately 5.5 cm long and provided with a narrow perforation with a diameter of about 0.5 cm that expanded at the bottom part to 1.1 cm (**fig. 3, a-b**). The specimen from Toruń-Gręboc in is decorated on the bottom part with two gentle grooves. An AMS dating of botanical samples from Toruń-Gręboc in (Bokiniec 1993a, 58) and Zieleń returned two radiocarbon dates: 3550±50 BP (Gd-7228) and 3470±40 BP (Poz-64426), with the respective date ranges of 2030-1740 cal BC and 1900-1640 cal BC, both to 95.4 % (**fig. 3, c**). These dates resonate well with ceramic evidence from the sites, indicating that the tuyeres were in use during the classic (2050/2000-1800 BC) and late (1800-1600 BC) phases of the Iwno culture.

Clay tuyeres are chiefly known from the late and final stages of the Únětice culture over a vast area of Central Europe, being largely produced in a settlement context, for example, Derenburg (Lkr. Harz/D) in Saxony-Anhalt or Slaný-Slánská hora (okr. Kladno/CZ) in Bohemia (Müller 1982, figs 5-8; Jiráň 2013, 50 fig. 21, 8-10). There is also a certain amount of evidence for the deposition of clay tuyeres that can be interpreted as part of a »metalworking toolkit«. The male burial from Erfurt-Gispersleben in Thuringia is a particularly well-known example (Müller 1982, figs 5-8). In northern Poland, clay tuyeres are known from the satellite groups of the ÚC, most of them coming from the defensive settlement of Bruszczewo (woj. wielkopolskie/PL) (Silska 2012a, 110-112 fig. 70). Further examples were found at the open settlements of Rybiny (woj. kujawsko-pomorskie/PL), Konin and Pietrzyków (both woj. wielkopolskie/PL) (Makarowicz 1998, 251-252 pl. 97, 1-4). The clay tuyeres from Chełmno land are interesting considering this issue because they were yielded by two opposite settlement types: one was found at the central and multi-phase settlement (Toruń-Gręboc in), while the other comes from a single household (Zieleń) which was an isolated spot in the settlement landscape in the region.

It has frequently been pointed out that clay tuyeres are related to bronzesmithing, and were utilised as nozzles for bellows, although it would be more accurate to see clay tuyeres as items attached to the end of blow-pipes (arguably made of reed) that were used to stoke the furnace (Jiráň 2013, 59-60). Except for the settlement of Bruszczewo, however, where an incomplete casting stone mould was accompanied by clay pads and casting spoons (Silska 2012a, 110-111 figs 69-71; 2012b, 117-119 fig. 79), no other casting and/or smithing accessories are known from the related EBA sites (cf. Makarowicz 1998, 251-252), meaning that the clay tuyeres are so far the single body of evidence[9] for local metalworking in northern Poland.

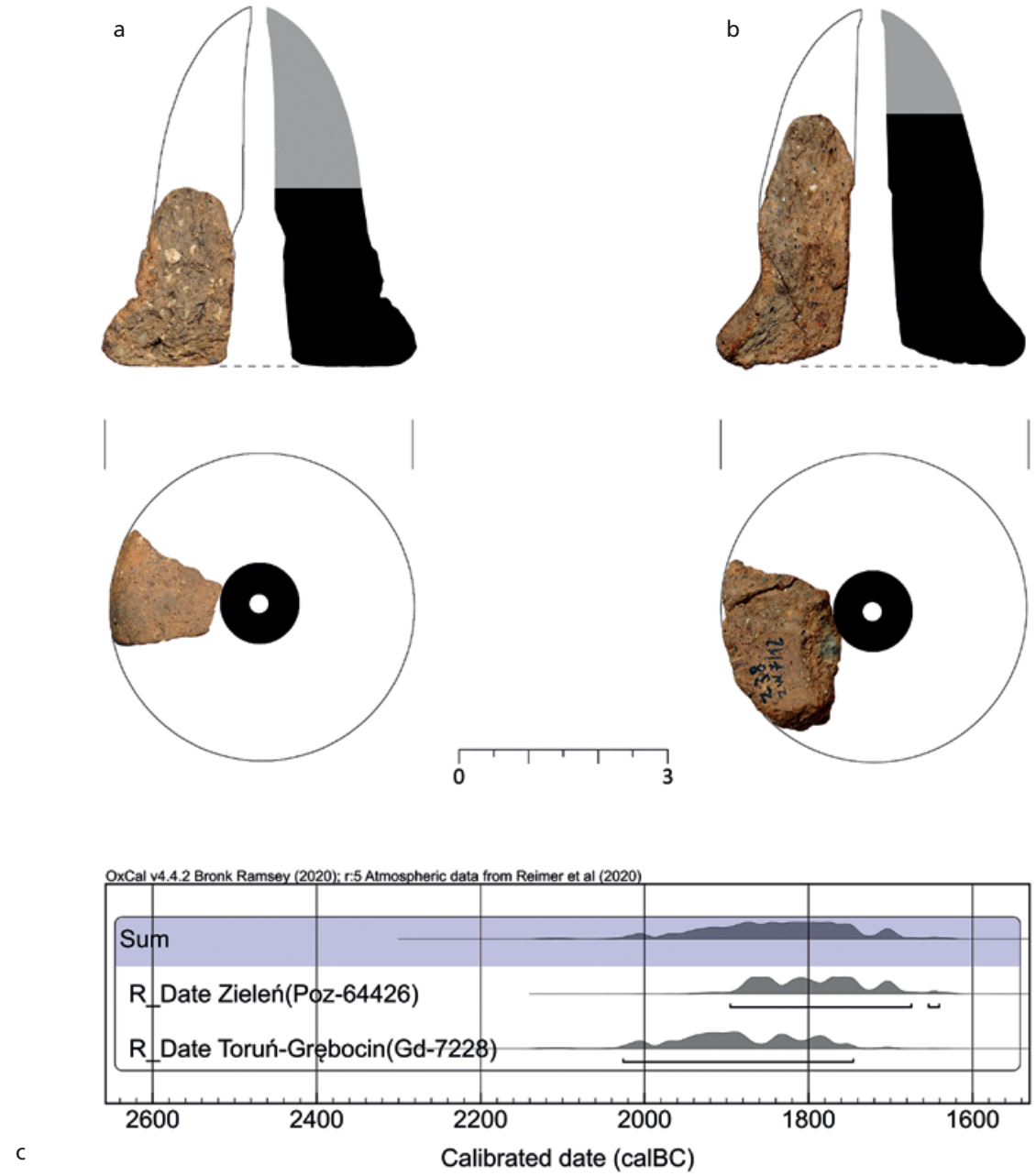

Fig. 3 Clay tuyeres from Chełmno land that can be linked to the Iwno culture: Toruń-Grębocin (**a**) and Zieleń (**b**). The AMS dating for the sites returned date ranges of 2030-1740 cal BC and 1900-1640 cal BC, both to 95.4 % (**c**), indicating that the tuyeres were used by the Iwno people during their classic (2050/2000-1800 BC) and late (1800-1600 BC) habitus in Chełmno land. – (a-b photos and drawings Ł. Kowalski; c OxCal v.4.4.2 after Bokiniec 1993a, 58). – a-b scale 1:1.

The Arrow Shaft Straightener

The arrow shaft straightener was re-made from a trapezoidal stone axe. It has a symmetrical longitudinal axis with an irregularly rounded butt, and the transverse axis is plano-convex with rounded and rubbed sides (**fig. 4**). Metrics: length 7.7 cm, width 5.9 cm, thickness 1.8 cm, weight 133 g. According to Karl Heinz Brandt (1967, 10), the analysed object can be assigned to Type 3 of the earliest stone axe industry in Central Europe[10]. There is a smooth and semi-oval groove measuring 5.6 cm in length, 1.3-1.5 cm in width, and

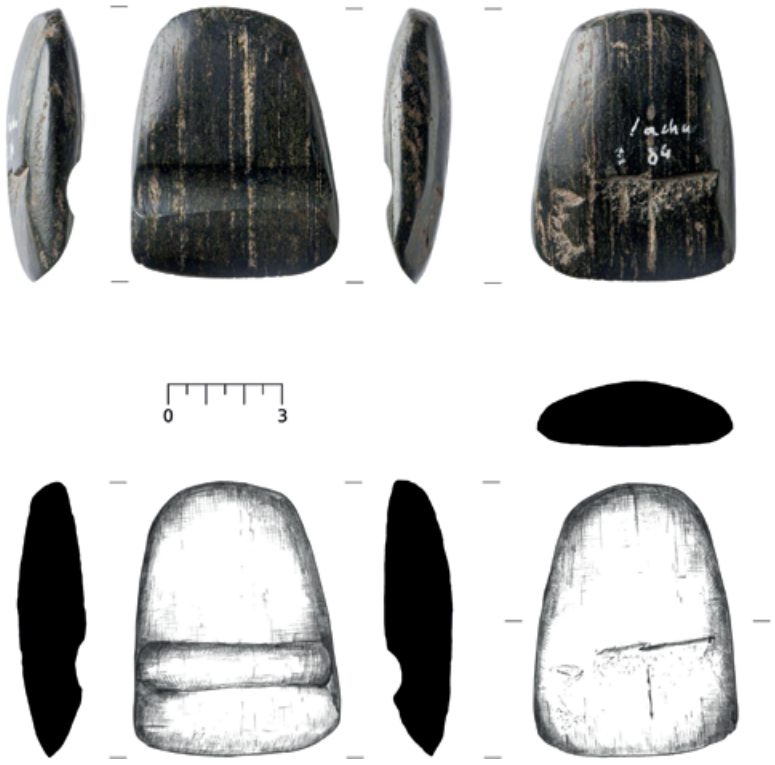

Fig. 4 Arrow shaft straigthener from Lachmirowice. The object is re-made from a Neolithic stone axe and was not found with any associated material or structures. Note the presence of a smooth groove along the object. – (Photos K. Deczyński; drawings B. Bielińska-Majewska; courtesy of the District Museum in Toruń). – Scale 1:2.

0.4 cm deep, running perpendicularly to the longitudinal axis of the object. The artefact is made of amphibolite (M. Krajcarz, personal communication 2020).

Trapezoidal axes are well attested in the Danubian stone industry, albeit technological aspects related to side rubbing are only evidenced for axes from the younger stages of *Linearbandkeramik* in Europe (Vencl 1960, 26; Czerniak 1980, 83). A small body of similar stone tools from the Czech Republic have also been defined as Bell Beaker (e. g. an axe from a male burial in Čachovice [okr. Mladá Boleslav/CZ]; Turek/Dvořák/Peška 2003, 195 fig. 12) or Beaker affiliated (for the axes from settlement contexts and stray finds see Turek/Dvořák/Peška 2003, fig. 13). The corresponding axes are also known from Poland: one specimen was found at the settlement of Rybiny in the Kuyavia region (Makarowicz 1998, 248 pl. 95, 3), and the other comes from Mieścino in Eastern Pomerania (Kurzyk/Ostasz 2015, fig. 9, 1-3). So, in terms of typology, the exact time frame of the production of the axe from Lachmirowice cannot be satisfactorily addressed. Similarly, petrographic evidence is not conclusive in differentiating between the Early Neolithic or Early Bronze Age terminus for production. This is because amphibolite was not only a favourite raw material used in the Danubian stone axe industry in northern Poland (Prinke/Skoczylas 1976, 53 tab. 1), but was also a frequent choice at the beginning of the Bronze Age (cf. Makarowicz 1998, 247-250).

The Dagger from Zwierzyniec

The dagger is generally in good condition, and a triangular and elongated blade part with ragged edges and no rib is preserved (**fig. 5**). The non-decorated blade is provided with a half-circular base which is topped with three evenly spaced rivet-holes, with the central hole pierced close to the edge of the base. The rivets are short metal rods (0.8-0.9 cm high) of 0.3 cm thickness with flat hammered heads that were originally

Fig. 5 Dagger from Zwierzyniec. The object can be assigned to the Vřesovice-Těšínov type and dated to the Br. A1b period; 1950-1700 BC. – (Photo Ł. Karczmarek; drawings B. Karch; courtesy of the Historical Museum in Przasnysz). – Scale 1:1.

passed through holes to join the blade part with a grip (e. g. Gediga 1978; Gedl 1980; Blajer 2001). There are no visible stains on the surface of the metal object to conclude that a handle was held in place by a binding agent. Metrics: total length 9.9 cm, max. width 3.9 cm, weight 28.7 g.

There is a direct parallel for the dagger from Zwierzyniec from the fortified settlement at Bruszczewo in Greater Poland, where a twin-like bronze dagger was found in a pit (Silska 2012b, 116 fig. 76)[11]. The corresponding metal objects are known from the Czech Republic (Novák 2011) and eastern Germany (Wüstemann 1995). Following the terminology proposed by Petr Novák (2011, 41-62 pls 5-8) the dagger from Zwierzyniec can be assigned to the Vřesovice-Těšínov type[12] and placed in the middle EBA period (= Br. A1b; 1950-1700 BC), which corresponds to the Głogów hoard horizon in Poland during the classical (= 5th) phase of the ÚC (Moucha 1963; Blajer 1990; Kowalski/Garbacz-Klempka/Dobrzański 2017). Such chronological placement agrees with a radiocarbon age of 3480±35 BP (Poz-48582) for the dagger from Bruszczewo, which falls into a calendar date of 1893-1693 BC to 95.4 % (Silska 2012c, 241 tab. 29).

The Dagger from Łęki Wielkie

This dagger is generally in good condition, and a handle connected to a triangular and elongated blade part with no rib and a damaged point is preserved (**fig. 6**). The blade is decorated on both sides with a gentle hatching which is arranged into a triangular motif narrowing towards the point. The solid handle consists

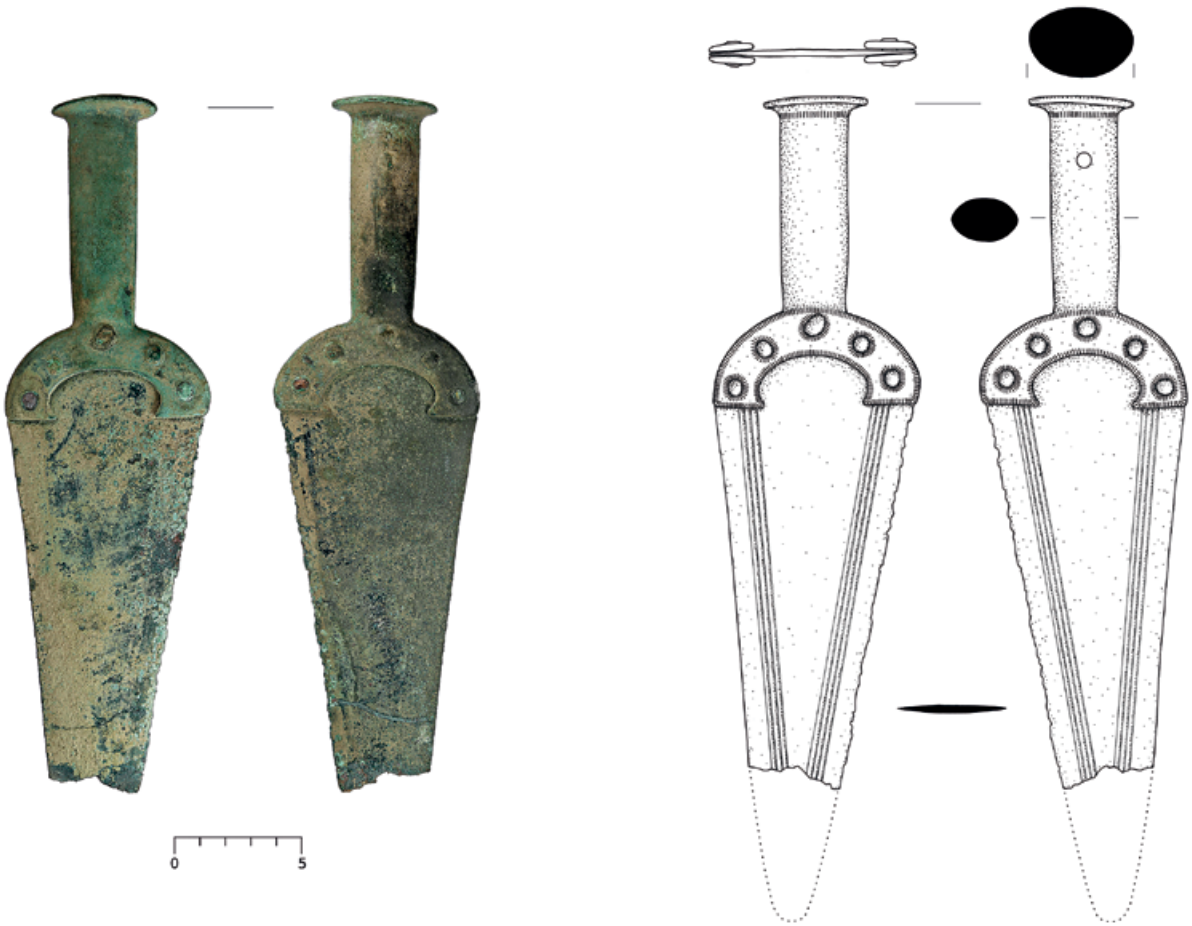

Fig. 6 Dagger from Łęki Wielkie. The object can be assigned to the Horoměřice type and dated to the Br. A1b-Br. A2 period; 1950-1600 BC. – (Photos P. Silska; drawings J. Kędelska). – Scale 1:3.

of a guard and grip that are covered with slight grooves and topped with a plate-like pommel. In the upper part, the grip is provided with an imitation rivet. Five evenly spaced rivets (1.0 cm high) with flat and hammered heads of 0.5-0.7 cm diameter were used to join the blade and handle together, each densely decorated with sunray motifs. Metrics: total length 24.7 cm (originally ca. 29.4 cm), max. width 7.4 cm, weight 341 g.

The dagger from Łęki Wielkie adheres to a wide group of Únětican daggers with handle, and more precisely to the Dobrcz variant distinguished by Marek Gedl (1980, 12-13 pl. 1; see also Sarnowska 1969, 74-75; Blajer 1990, 31; Wüstemann 1995, 45-48 pl. 1; Wels-Weyrauch 2015, 68 pl. 10). Following the terminology proposed by Novák (2011, 71-73 pls 19-21), the dagger can be assigned to the Horoměřice type[13] and placed in the younger stages of the EBA period (= Br. A1b-Br. A2; 1950-1600 BC), which corresponds to the Głogów-Pilszcz hoard horizon in Poland during the classical and final (= 5th-6th) phases of the ÚC (Moucha 1963; Blajer 1990; Kowalski/Garbacz-Klempka/Dobrzański 2017; see also Uenze 1938).

The Dagger from Szczytniki Duchowne

This dagger is badly damaged and includes a partially preserved lancet blade with ragged edges and no rib (**fig. 7**). We can learn from a hypothetical reconstruction that the blade may originally have been ap-

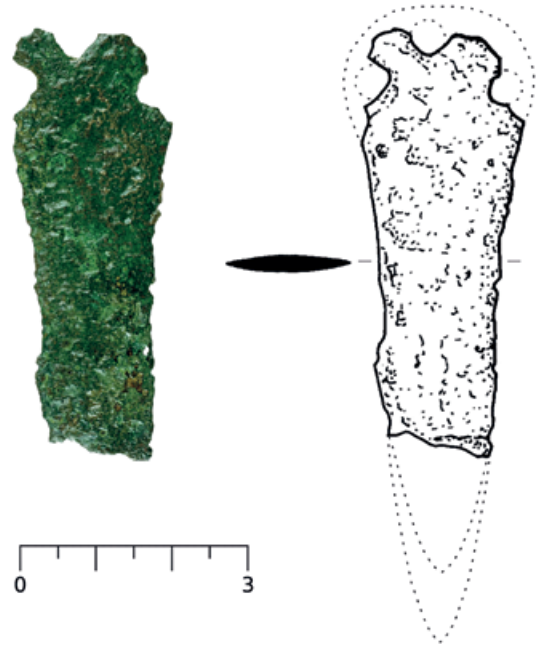

Fig. 7 Dagger from Szczytniki Duchowne. The object can be traced to the Hurbanovo group from Slovakia and dated to the Br. A2 period; 1700-1600 BC. – (Photo K. Kucharska; drawing J. Kędelska). – Scale 1:1.

proximately 7.5-8.5 cm long and provided with a fan-shaped base that was topped with three evenly spaced rivet holes. Metrics: total length 6.5 cm, max. width 2.1 cm, weight 8 g.

While the typo-chronology of daggers from Zwierzyniec and Łęki Wielkie can be successfully positioned, it is difficult to provide equally comprehensive information about the dagger from Szczytniki Duchowne. We can indicate only a limited number of more or less convincing analogies from Central Europe. A formal correspondence can be drawn between a bronze dagger blade from Bystrzek near Śrem (woj. wielkopolskie/PL) and the specimen from Szczytniki Duchowne (Knapowska-Mikołajczykowa 1957, 37-38 fig. 14; Gedl 1980, 43 pl. 12, 82). There are also some examples of ribbed triangular daggers from Mecklenburg, Brandenburg and Saxony-Anhalt that belong to the Deutschof-Schmerzke type (Wüstemann 1995, 96-97 pls 35. 65, A), and bronze daggers linked to the Hurbanovo group[14] from Slovakia (Vladár 1974, 32-34 pl. 4). On the whole, the dagger from Szczytniki Duchowne stands out from the classical ÚC metal industry, showing a much greater similarity to the weaponry that was produced at the beginnings of the MBA in Central Europe (cf. Krzyszowski et al. 2017). In acknowledging this evidence it would be plausible to suggest a 1950-1700 BC date range (= Br. A1b) as a *terminus post quem* for the production of the analysed dagger, pushing it into the final stages of the EBA period (= Br. A2; 1700-1600 BC), which corresponds to the Pilszcz hoard horizon in Poland during the final (= 6th) phase of the ÚC (Moucha 1963; Blajer 1990; Kowalski/Garbacz-Klempka/Dobrzański 2017).

ANALYTICAL METHODS

The freshly exposed and cleaned surfaces of the metal objects were analysed for elemental concentrations (Fe, Co, Ni, Cu, As, Ag, Sn, Sb, Pb and Bi) using a Spectro Midex spectrometer equipped with a molybdenum X-ray tube and a Si Drift Detector (SDD), with 150 eV resolution at 5.9 keV, and a portable μ-XRF spectrometer Artax (Bruker) equipped with a rhodium X-ray tube and Si Drift Detector (SSD) with 150 eV resolution for Mn-Kα. The selected artefacts were checked by X-ray radiography with the use of Smart 160 devices from Yxlon equipped with a metal-ceramic lamp operating at 10-160 kV and 2-6 mA. The metalwork was also examined for casting and plastic forming defects using a Nikon SMZ 745Z stereoscopic microscope.

Samples of inlaid decoration and post-depositional contaminant were carefully separated from the ceramic vessel and screened for major and minor elemental composition (C, O, Mg, Al, Si, P, K, Ca and Fe) using a low-vacuum (50 Pa) scanning electron microscope LEO 1430VP (Zeiss) coupled with the EDS spectrometer Quantax 200 with XFlash 4010 detector (Bruker AXS). The SEM-EDS investigations were conducted in semi-quantitative, surface and standardless mode with non-conducting material imaging. The micro-imaging was applied to the non-coated sample using a high-resolution Quanta 3D FEG (FEI) scanning electron microscope coupled with a LVSED detector operating at 30 kV accelerating voltage and low-vacuum (50 Pa).

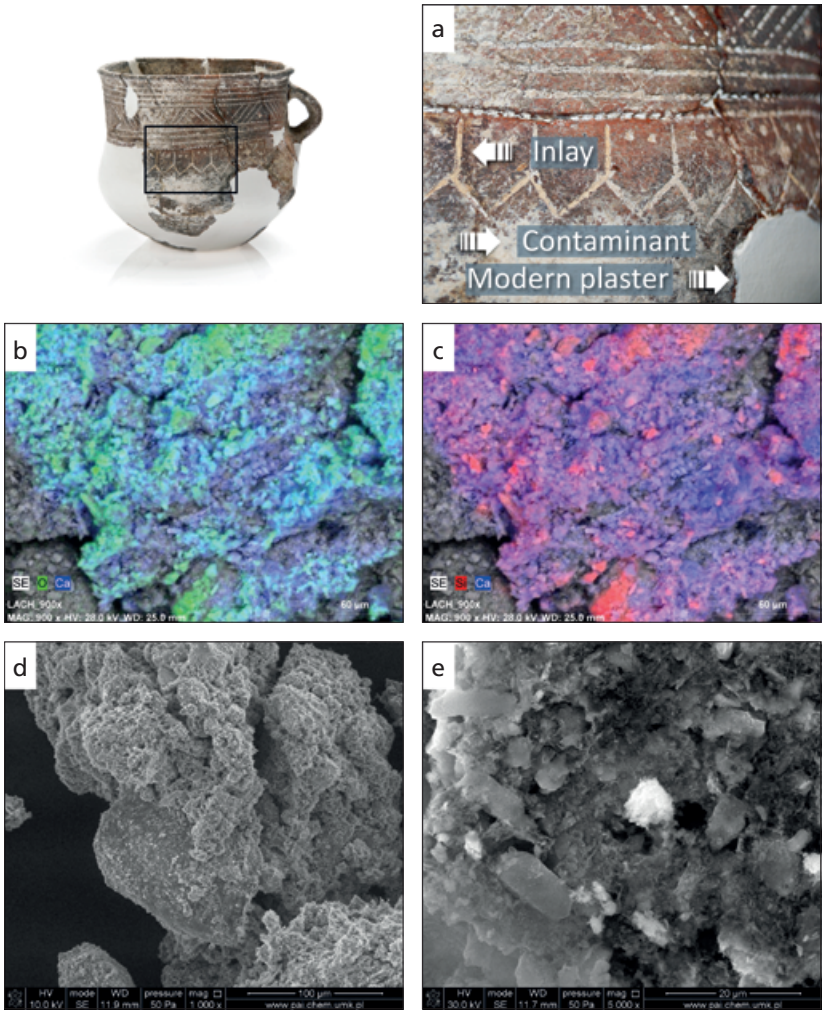

Fig. 8 The SEM-EDS images of the material inlaying the Beaker pot from Lachmirowice. Note the co-occurrence between SiO_2 and CaO (**b-c**), and the presence of carbonate incrustations on quartz grains (**d-e**), indicating that limestone or secondary carbonate concretions from the loess or silty clays could have been a possible starting material used for the paste inlay. The images were taken at magnification ×900-5000 under a low-vacuum mode and an accelerating voltage of 10.0-28.0 kV. – (Photos K. Deczyński; courtesy of the District Museum in Toruń; SEM/BSE recordings G. Szczepańska).

The arrow shaft straightener was examined for technological and use-wear traces to identify the possible function of the object. A Nikon SMZ-745T optical microscope (magnification up to ×50) coupled with a Delta Pix Invenio 6EIII camera was first used to investigate the condition of the artefact, as well as the technological traces and general characteristic of its surface. The analysis of polish then used a metallographic microscope Zeiss Axioscope 5 Vario (magnification up to ×500) coupled with an Axiocam 208 camera.

RESULTS AND DISCUSSION

The Pottery

The remains of beige paste are preserved inside the decorative incisions in the middle part of the Beaker cup (**fig. 8, a**), and contamination by modern plaster applied during conservation treatment is also observable on the vessel. A white crust on the ceramic body signals the presence of a post-depositional contaminant. The results of the SEM-EDS investigations show that the sample is composed primarily of CaO ranging from 73 % to 90 % (**tab. 1**), which suggests that the crust on the ceramic body was formed by calcium salts during burial conditions.

Sample	CO_2	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	Fe_2O_3
Inlay	48	1.7	5.9	23	0.76	2.0	16	3.1
	40	2.4	6.1	24	1.3	1.9	21	2.8
	31	3.4	10	22	2.3	1.4	25	5.2
Contaminant	11	2.0	1.7	5.1	4.4	0.73	73	1.5
	12	1.8	1.7	4.7	2.5	0.66	75	1.5
	3.9	1.3	0.48	1.2	1.3	0.73	90	1.0

Tab. 1 Results of the SEM-EDS analyses of inlaid decoration and contaminant sampled from the Beaker cup from Lachmirowice. The mean values were recalculated from three measurements and normalised to 100 %.

The CaO content in the paste ranges between 16 % and 25 %, which combined with the low amount of P_2O_5 (up to 2.3 %) precludes the use of bone paste as a decorative agent (**tab. 1**). The inlay material is dominated by CO_2 and CaO (**fig. 8, c**), with a variation of between 56 % and 64 %, indicating the use of crushed carbonate rock or carbonate-bearing clays and/or soils. The material possibly used to start the paste could be limestone or secondary carbonate concretions from the loess or silty clays, which are one of the most common inlay raw materials (among kaolin, bone, and gypsum) employed by Beaker people for pottery decorating (Všianský/Kolář/Petřík 2014, 418-421; see also Odriozola/Hurtado Perez 2007). The latter use can be demonstrated by the chemistry of the paste, and further supported by the SEM recordings, showing the carbonate incrustations on quartz grains and clay-particle aggregates (**fig. 8, d-e**). However, there is a possibility that the paste preserved on the cup from Lachmirowice is not an inlay material but a contaminant from a ceramic body or burial conditions (cf. Všianský/Kolář/Petřík 2014, 418-419).

The Arrow Shaft Straightener

The geometry of the artefact indicates that it may have originally been a shaft-hole axe. This is largely supported by the hour-glass shape of the groove (see **fig. 4**) which also has minor surface damage and small cavities on the entrances (**fig. 9, a**), indicating that the starting object could be perforated with the use of a core drill bit and abrasive sand material. These two technological dealings are typical strategies in the Neolithic stone industry. Traceological analysis failed to identify typical drilling traces (**fig. 9, b**; cf. Osipowicz 2005, figs 7-8) but these cannot be taken as conclusive evidence because such traces could have been smoothed during the (re-)usage of the object. This would mean that the axe from Lachmirowice was remade from a fragment of a broken shaft-hole axe.

Numerous traceological patterns are preserved on the object from Lachmirowice, that can be linked to the second stage of its use: (i) grinding the surface of the object (**fig. 9, c**), (ii) secondary (recovering) grinding the blade part (**fig. 9, d**), (iii) polishing of the blade part (**fig. 9, e**), and (iv) traces on the axe's butt, demonstrating that some kind of handle was attached (**fig. 9, i**). While the third of these technological dealings (polishing) is rarely found on the earliest stone axes from Central Europe, the others are typical of the Neolithic axe industry.

In terms of technology, there are no strong arguments against the possibility that the object from Lachmirowice was made in full by a Neolithic craftsman. Many examples of plano-convex stone tools are known from Central Europe that are provided with a linear grove, and their chronology spans from the Neolithic into the Early Iron Age (Horáková-Jansová 1933, 53; Vencl 1960, 40-45; 1964; Kozłowski/Kulczycka 1961, 39 pl. III,

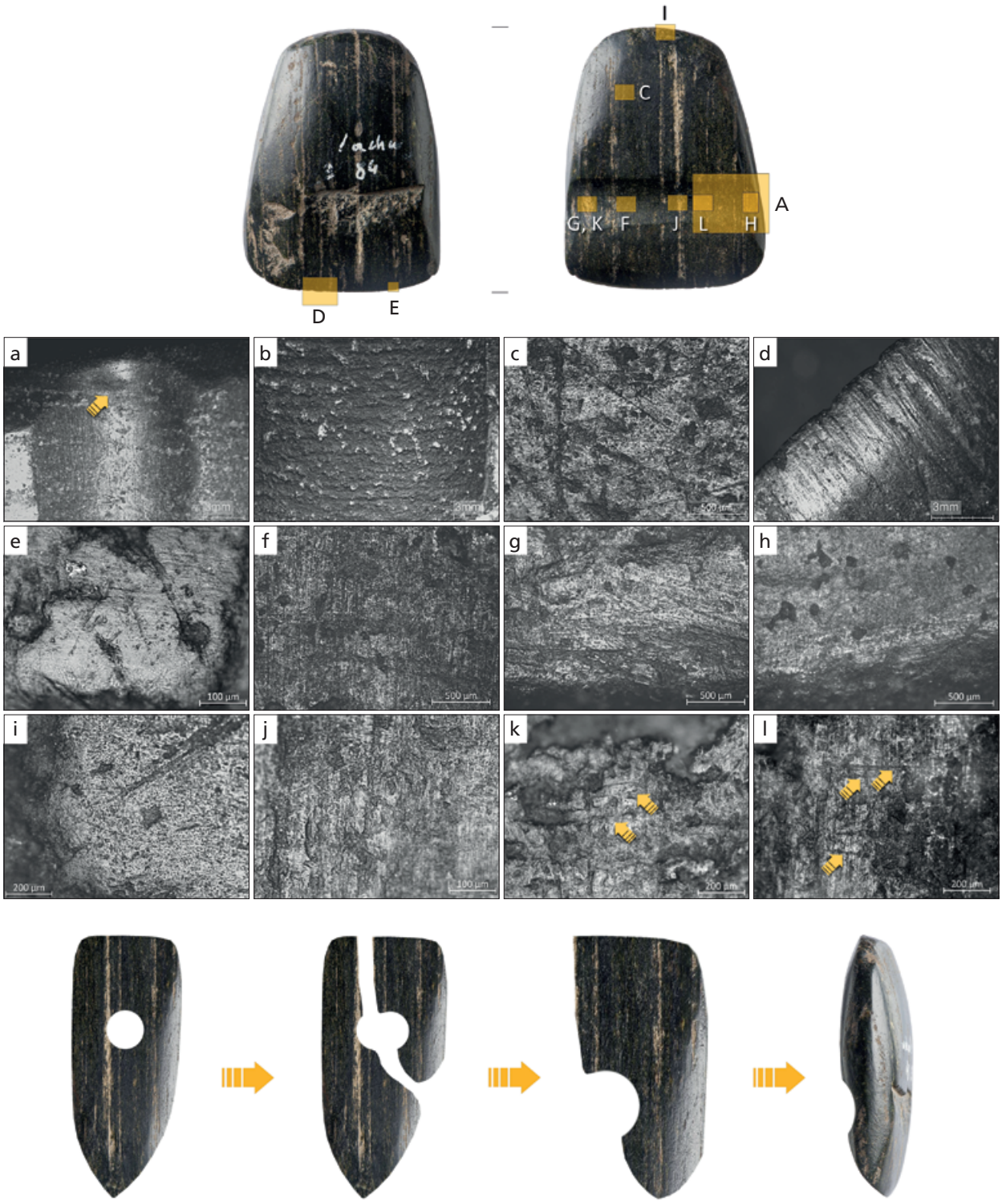

Fig. 9 Photomicrographs of the arrow shaft straightener from Lachmirowice showing technological traces and evidence of technological use-wear with a *chaîne opératoire* that may explain the biography of the artefact. Note the presence of a secondary polish in the middle part of the groove (**j-l**) with longitudinal (**j**) and perpendicular (**k-l**) striations that could have been formed when smoothing the wood shaft of an arrow in the groove. The images were taken at magnification ×50 and ×500 using optical (**a-b. d**) and metallographic (**c. e-l**) microscopes. – (Photos G. Osipowicz).

Site	Microarea	Fe	Co	Ni	Cu	As	Ag	Sn	Sb	Pb	Bi	Imp.	Method
Zwierzyniec	Blade	0.15	0.04	0.11	97	0.46	1.0	0.10	0.61	DL	0.04	2.4	ED XRF
	Rivet	0.22	0.05	0.12	95	0.46	1.0	1.8	0.79	DL	0.06	2.7	
Łęki Wielkie	Blade	0.09	DL	0.50	88	0.34	0.20	8.7	1.7	0.13	0.02	3.0	µ-XRF
	Rivet	0.10	DL	0.15	96	0.95	0.24	0.09	2.4	0.22	0.03	4.1	
	Handle	0.16	DL	0.15	94	1.2	0.26	0.09	3.4	0.16	0.07	5.4	
Szczytniki Duch.	Blade	0.22	0.12	0.34	87	0.30	0.05	11	0.29	0.21	0.01	1.6	µ-XRF

Tab. 2 Elemental composition of the daggers given in wt % as mean values recalculated from five measurements. »Imp.« is the total sum of the impurities. »DL« indicates results at, or below detection limits.

2-3; Bolus 2012, 531 fig. 2, 6-9). A widely held belief is that such implements were used in a wide range of applications in the past, but these are often speculations without any firm traceological or experimental evidence. Linked to this problem, we identified distinct striations on the artefact from Lachmirowice, which respect the longitudinal course of the groove (**fig. 9, f**), and these technological traces only drift off that course at the mouths of the groove (**fig. 9, g-h**). Further examination of the artefact revealed the presence of a secondary linear polish in the middle part of the groove, which partially covers the previous microrelief formed by grinding the body of the axe. The secondary polish has a domed or almost flat topography and shows a smooth texture (**fig. 9, j-l**). Added to this are agglomerating filled in striations and single black striations, which mostly respect the longitudinal course of the polish (**fig. 9, j**), and only in some parts of the groove do they run perpendicular (**fig. 9, k-l**). These linear traces are similar to those observed on stone tools that are interpreted as arrow shaft straighteners (cf. Usacheva 2016, 599 figs 7-8), and that could be formed by smoothing the wood shaft of the arrow in the groove. Arrow shaft straighteners are well attested in Bell Beaker assemblages across much of Europe and are usually seen as archery equipment (e. g. Harrison 1980; Czebreszuk 2001). In Poland, an arrow shaft straightener was found in a male burial from Beradź near Sandomierz (woj. świętokrzyskie/PL; Budziszewski/Włodarczak 2010, 52-53 pl. VI, 5.5-5.6), but objects of this type are more often stray finds or come from settlement contexts, such as the arrow shaft straightener from the settlement of Rybiny (Makarowicz 1998, pl. 95, 6).

There are therefore two possible explanations for the artefact from Lachmirowice: either we consider that Bell Beaker or related Iwno people from Kuyavia became the new owners of an Early Neolithic axe provided with a groove and customised it as an arrow shaft straightener, or that there is no significant timing between the production and functional modification of the axe, and that we should push both these technological dealings into the Early Bronze Age. Anyway, there are objective chronological and typological indications to connect the pottery and arrow shaft straightener from Lachmirowice with the residence of a Bell Beaker group at the site.

The Daggers

Elemental Characterisation

The ED XRF analyses show that the blade from Zwierzyniec is made of copper with tin as trace element (cf. Vandkilde 1996, 30), making a mere 0.1 % (**tab. 2**). The tin content is higher in a rivet than in the blade, but not unusually so (in terms of ED XRF), as a compositional variation produced by the surface enrich-

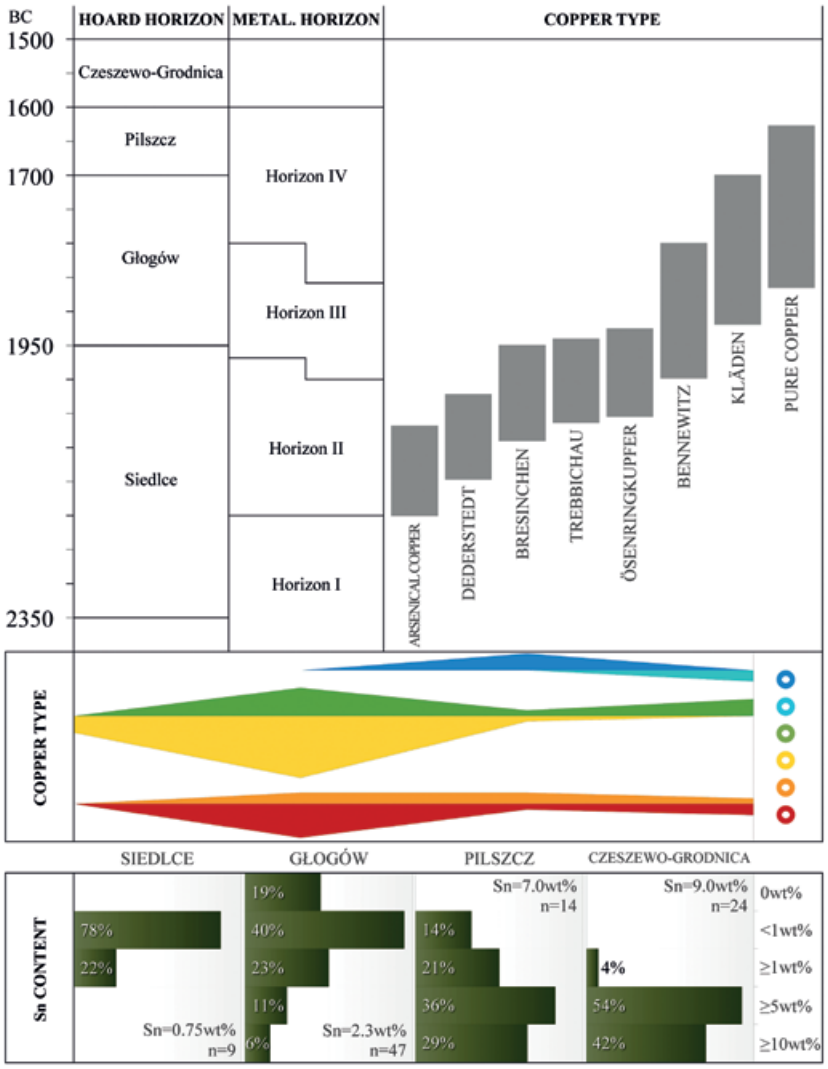

Fig. 10 Schematic overview of EBA and EBA/MBA chronologies in Poland, showing the variability in copper metal type and tin alloying. – *Ösenringkupfer* I (A34: 1). – arsenical copper (A34: 3). – Eastern Alpine copper (A34: 4). – pure copper (A34: 5). – *Singen* copper (A34: 8). – *Ösenringkupfer* II (A34: 10). – (Compiled after Otto/Witter 1952, 136 tab. 14b no. Z 481; Sarnowska 1975, 102-112 tabs I-V; Blajer/Szpunar 1981; Szpunar 1987, 20-35 pl. 57; Blajer 1990, 19-21; 2001, 259-268; Vandkilde 1996, 139-143 fig. 134; Krause 2003, 83-85. 90 fig. 40; Rassmann 2010a, 809. 812 figs 1. 4 tab. 1; 2010b, 712 fig. 1; Silska 2012b, 115-121 tab. 9; Kowalski/Garbacz-Klempka/Dobrzański 2017, 573 fig. 17 as amended).

ment (Pollard/Heron 1996; see Davis 2001 and Scott 1991 for the inverse segregation in copper alloys) or resulting from the use of re-melted scrap bronze. With silver, antimony and arsenic making a major contribution, the total content of impurities is significant (2.4-2.7 %) and indicative of copper smelted from *Ösenringkupfer* (A79: 25; Krause 2003, 308). Studies of the fahlore copper industry in Central Europe are interesting with regard to this issue because they indicate that low-tin and/or tin-free alloying was a common choice for the mainstream flanged axes of the Wrocław-Szczytniki type, and that furthermore this choice was not necessarily due to limited access to tin minerals, but could result from technological and casting advantages of fahlore copper[15], which closely resembles bronze alloy (Kienlin 2011, 128-135; Kowalski/Garbacz-Klempka/Dobrzański 2017, 577; see also Kowalski et al. 2019).

A metal type characteristic of the dagger from Zwierzyniec correlates chemically with *Bresinchen* copper distinguished by Knut Rassmann (2010a, 809-814 fig. 1 tab. 1) for the metallurgical horizon (MH) III, dating to 2100-1950 BC (= Br. A1a) (**fig. 10**). This seems to interfere with the previous typo-chronological placement that pushed the dagger into the middle EBA period (= Br. A1b; 1950-1700 BC). Such a contradiction may, however, result from the long-term circulation of fahlore copper in the ÚC peripheries (Kowalski/Garbacz-Klempka/Dobrzański 2017, 575; see also Nørgaard/Pernicka/Vandkilde 2019; 2021),

Fig. 11 Flanged axe from Gniew. The axe was cast from *Dederstedt* copper dating to 2150-2050 BC, although the object can be safely placed in the Late EBA/MBA (= 1700-1600/1500 BC). – (Photo Ł. Kowalski; courtesy of District Museum in Toruń). – Scale 2:1.

which is in no way exceptional. For instance, this can be evidenced by a flanged axe from Gniew near Tczew (woj. pomorskie/PL) (**fig. 11**), which was cast from *Dederstedt* copper dating to 2150-2050 BC (Rassmann 2010a, 809-814 fig. 1 tab. 1; Suchy et al. 2016, 153 tab. 1), albeit the typo-chronology makes it plain that this object was produced at the turn of the EBA and MBA (= 1700-1600/1500 BC) (Szpunar 1987, 47-49 pls 14-15. 36, B).

Antimony clearly stands out as the dominant impurity in the individual parts of the dagger from Łęki Wielkie, averaging between 1.7-3.4 % (**tab. 2**) and indicating the use of fahlore copper. The trace elemental composition links the dagger to *Ösenringkupfer* (A79: 16; Krause 2003, 306), which also closely resembles the *Bennewitz* copper that is characteristic of the MH III during 2000-1800 BC (= Br. A1b) (Rassmann 2010a, 809-814 fig. 1 tab. 1). The blade is separated from other parts of the dagger by a tin content of 8.7 %. In contrast, the handle and rivet present a much lower amount, making a mere 0.09 %. This is in line with a bimodal distribution of tin that is observable for the Głogów horizon in Poland (= 1950-1700 BC), for which 63 % of metal finds do not show features of an alloy, and in only 10 % of the cases does the tin content reach 8 % or more (Kowalski/Garbacz-Klempka/Dobrzański 2017) (see **fig. 10**). These technological differences in the dagger from Łęki Wielkie may reflect the manipulation of alloy to obtain the particularly utilitarian (hard cutting edge) and aesthetic (gold colour) properties of the blade and finished product. The same technological pattern can be seen in the Únětican dagger from Kotla near Głogów (woj. dolnośląskie/PL; Gedl 1980, 13 pl. 1, 7; Krause 2003, FMZM 2040. 2043).

The results show that the dagger from Szczytniki Duchowne is made of copper alloy, with considerable tin content making up to 11 % (**tab. 2**), which ties well with the general bronzesmithing trend during the MH IV in the central area of the ÚC, showing the stabilisation of tin content in bronzes at 8-12 % (Krause 2003, 84 fig. 34; Kristiansen/Larsson 2005, 123-125). This technological trajectory also matches the Pilszcz horizon in Poland, for which 29 % of the metal artefacts are high tin bronzes with a tin content at or above 10 % (Kowalski/Garbacz-Klempka/Dobrzański 2017; see also Pare 2000). The total amount of impurities in the analysed object is a mere 1.6 % and is indicative of oxidised/sulphidic copper ore, which links the dagger from Szczytniki Duchowne to pure copper (*Reinkupfer*) distinguished by Rassmann (2010a, 809-814 fig. 1 tab. 1) for the MH III/IV-IV (= 1850-1600 BC). This is in line with the consumption of copper metal during the Pilszcz horizon, which was dominated by *Ösenringkupfer* and pure copper (see **fig. 10;** cf. Nørgaard/Pernicka/Vandkilde 2019; 2021), thus indicating the Br. A2 period (= 1700-1600 BC) as a possible date range for the production of the dagger.

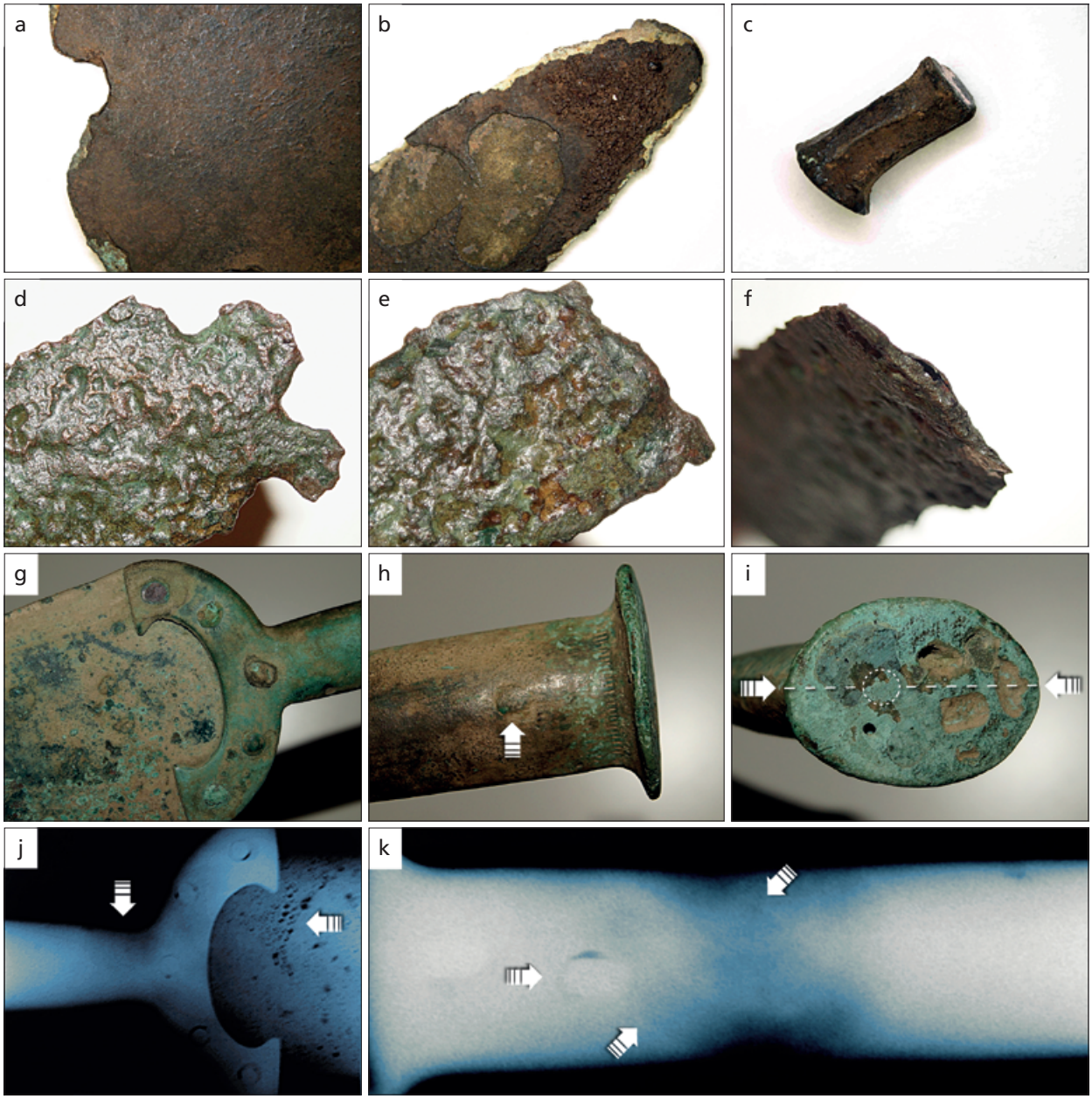

Fig. 12 Photomacrographs of the daggers with X-ray recordings, showing evidence of casting and plastic forming: **a-c** Zwierzyniec. – **d-f** Szczytniki Duchowne. – **g-k** Łęki Wielkie. – Note the presence (**k**) of the imitation rivet in the middle grip of the dagger from Łęki Wielkie and the two metal bands twisted around a clay core that could be used to strengthen the guard. – (Photos A. Garbacz-Klempka; X-ray recordings P. Gan).

Technological Characterisation

The dagger from Zwierzyniec presumably went through a *chaîne opératoire* that involved casting, forging and annealing, and then the blade part was fitted into a handle using three rivets (**fig. 12, a**), which were hammered flat on one side only (**fig. 12, c**). The blade point is round-tipped and both edges are ragged (**fig. 12, b**), which may signal the intensive use of the object in prehistory. The *Ösenringkupfer* used for the dagger is notable for having a relatively high rate of silver, antimony and arsenic (see **tab. 2**), which would compensate for the absence of tin minerals in the melt used, mainly due to the positive effect of these ele-

ments on the castability and hardness of copper alloys, and lowering the crystallisation temperature upon casting. In contrast, the blades from Łęki Wielkie and Szczytniki Duchowne are made of castable bronze alloys, which are noted for their advantageous mechanical properties and reducing effect on casting shrinkage (Garbacz-Klempka et al. 2015; Garbacz-Klempka 2018).

The blade from Szczytniki Duchowne is badly damaged and firmly covered with corrosion products, which hinder the identification of the plastic working employed (**fig. 12, d-e**). Arguably, the object was cast, then forged and annealed. The photomacrographs show that the blade is much more pronounced in the middle part (**fig. 12, f**), and the partially preserved fan-shaped base suggests that three rivets were hammered to connect the blade with a handle (**fig. 12, d**).

A closer look at the dagger from Łęki Wielkie shows that the handle and blade were made separately. The handle could be cast with a core using the lost-wax casting technique. The X-ray recordings identified the presence of two metal bands twisted around a clay core (**fig. 12, k**) that could be used to strengthen the guard. The absence of a casting seam on the pommel and guard is indicative of lost-wax casting (**fig. 12, h-i**), and may suggest that the gating system that was originally located on the pommel was removed in the final stage (similar examples from Central Europe can be found in Gedl 1980 and Wüstemann 1995). These photomacrographs also suggest that the mould used for the analysed object was made of a bronze dagger with a two-piece handle, as can be seen from slight and offset deformations on the pommel, which are presumably the exact negative of the original model (**fig. 12, i**). The middle of the blade is flat and much larger, while the edges are much thinner and have a contoured shape, which may have been the result of casting or subsequent plastic working, although both the geometry of the casting and the chemistry of the alloy indicate that the blade was not forged. The X-ray radiography also showed an agglomeration of porosity in the base of the blade (**fig. 12, j**), which is probably due to the gaseous melt that was used for casting. After casting, the blade was pierced, fitted into a guard and stabilised with rivets (**fig. 12, g. j**), but only the two outermost rivets and one central rivet are of technical significance[16], the other two, although going through the guard, are instead decorative items (cf. Wels-Weyrauch 2015, pl. 10, 145), and the same can be true for the rivet in the upper part of the grip (**fig. 12, h. k**), which is probably a moulding of the rivet from the original model.

FINAL REMARKS

The artefacts presented in this paper signify different stages throughout the Early Bronze Age in northern Poland, and they reflect close relationships between the communities from the lowlands and lake districts of northern Poland and their partners and/or patrons from the »Central European Early Bronze Age civilization«, in the words of Jan Machnik (1978). Although the main corpus of this study are the objects found with little or no associated material or structures, they still resonate well with different models of inflow and consumption of new cultural patterns in the region of northern Poland at the beginnings of the Bronze Age.

Northern Poland is considered the north-eastern frontier of the Bell Beaker culture in Europe (Czebreszuk 2001; Manasterski 2016). Evidence for the Bell Beaker appearance can be found in many regions of Poland, but a clear concentration has been identified in Kuyavia (Kośko 1979; Czebreszuk 1996; 2001). Currently, the dominant view is that the Bell Beaker people who arrived in this region were migrants from the territories that are today Denmark and northern Germany (Czebreszuk/Szmyt 2012, 159 figs 1-2, and refs.). The survey evidence indicates that the one-handled cup from Lachmirowice breaks this concept by resembling the pottery from Bohemia and Moravia. This brings a further argument against the monogenetic model for

the Bell Beaker migrants in northern Poland, as they seem to arrive from many directions at the same time[17]. Here, it is worth noting that the plastic moustache motif that is discernible on the cup from Lachmirowice heralds the decorative style that would later become a signature mark of the Iwno culture potters (e. g. Makarowicz 1998, pl. 79, 1).

Going further, it is possible to observe through the artefacts analysed in this study how local post-Neolithic communities from northern Poland found their way to enter the Únětican orbit, and eventually became an integral part of this world-system, or what Helle Vandkilde (2017) calls the Únětican *koiné*. This is how the Kościan group is understood today (cf. Jaeger/Czebreszuk 2010). As a consequence of this close integration, a secondary centre was established at Bruszczewo in Greater Poland, where metal products from the ÚC workshops were consumed and/or redistributed, and it may well be that daggers from Łęki Wielkie and Zwierzyniec are additional pieces of this puzzle.

This brings us to the »Iwienisation« model proposed by Kośko (1979), which marks a breakthrough in understanding the beginnings of the Bronze Age in northern Poland. According to this model, the groups of the Iwno culture intermediated in trading the Únětican metal products in the north, and Baltic amber in the south. Accordingly, the western zone of the Iwno dominium (i. e. the Pałuki region) became the central node in the region handling Únětican metalwork and serving Kuyavia, Krajna and the Lower Vistula, which were a buffer zone between the Iwno people and the post-Neolithic communities. There is evidence that Únětican metalwork was distributed further east by Iwno middlemen, as exemplified by a bronze halberd from Veliuona (Šiauliai apskritis/LT) in western Lithuania or the *Ösenhalsringe* found near Kętrzyn (woj. warmińsko-mazurskie/PL) in the Masurian Lake District (Dąbrowski 1968, 47. 70 pl. II, 1-2), and it seems most probable that the bronze dagger from Zwierzyniec fits neatly into this pattern too. In turn, the clay tuyeres yielded by the satellite groups of the ÚC from northern Poland may indicate that household metal production was launched in the region during the classic (2050/2000-1800 BC; Toruń-Gręboc in) and late (1800-1600 BC; Zieleń) phases of the Iwno culture. This, however, must remain speculative until there is more conclusive evidence of local bronzesmithing from the region and it is therefore reasonable to assume that the Iwno decision-makers were arguably not interested in taking advantage of the technological opportunities of the era to develop local metallurgy, unlike communities more integrated into Únětice region, for example, the Kościan group in Greater Poland.

A much stronger background in archaeological evidence suggests that a local metallurgical centre was established in Eastern Pomerania during the later stages of the EBA, which could operate as a nodal zone trading Únětican metal products further eastwards (Bokiniec 1995, 94-95). Apparently, the collapse of the ÚC world-system around 1600 BC did not inhibit this centre, as it now focused on producing and distributing local types of bronze axes, including the Ubiedrze and Łuszczewo types (cf. Sobieraj/Hoffmann 2019). At the end of the Únětican era in Poland, the region of Eastern Pomerania gained some organisational independence which was secured by new distributive channels for metal flow, including these running from the late Hurbanovo group in Slovakia (Bokiniec 1995, 95). It was precisely at this time that the »Iwienisation« process accelerated, and hence it would be reasonable to expect that the dagger from Szczytniki Duchowne is a product of this new cultural landscape.

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Notes

1) The term »northern Poland« is used here for the area covering the broad lowlands and lake districts to the south of the Baltic Sea.

2) The cultural landscape of the Early Bronze Age in Poland presented in »The Past Societies« series (Bugaj 2017; Włodarczak 2017) should be taken with a pinch of salt, as it has marginalised the role of the Iwno culture and Płonia group, and many other past societies from northern Poland that are essential for understanding the complex picture of the Early Bronze Age in Poland.

3) Important works summarising the beginnings of the Bronze Age in Eastern Pomerania were published in the 1990s (Bokiniec 1995; Bukowski 1998).

4) A bronze pin (Wyrostkiewicz 2014), a long dagger linked to Montelius III (Kostrzewski 1962, 12. 32. 99 pl. VII, 1; Gedl 1980, 65 pl. 20, 181) and a metal hoard dating to the Early Iron Age (Borkowski/Miecznikowski 2018, 39 fig. 11; Skarb z Drążdżewa 2020) were discovered in the vicinity of the Płaska Góra (woj. mazowieckie/PL).

5) Although there is little information about the context of the discovery, the pottery from Lachmirowice will hereafter be referred to as a closed assemblage.

6) The knurling technique (*vel* roulette decoration) is generally a hallmark of Bell Beaker pottery. In northern Poland, ceramic wares with a roulette decoration are added as Bell Beaker or Beaker affiliated (cf. Czebreszuk 1996; 2001).

7) A similar cultural pattern can be traced to Mecklenburg-Vorpommern, where Pinnow pottery is found that merges three different ceramic styles: Single Grave, Bell Beaker and proto-Únětican (e. g. Jacobs 1991).

8) According to the ceramic typology of the Corded Ware culture from the Lower Oder, both beakers from Lachmirowice can be assigned to Type 1.7.3.1.2 (Matuszewska 2011, 76-77 fig. 26).

9) Except for the finds from Bruszczewo, archaeological evidence that metalworking had begun in northern Poland in the Early Bronze Age is very ambiguous, which is fuelled by the overall absence of waste slag, melting droplets, and casting and/or smithing accessories in the region. In this context, the appearance of clay tuyeres is puzzling and raises additional issues about the function and origin of these objects. Their presence in the EBA settlements from northern Poland may be a result of metalworking know-how transfer that led to an initial/experimental bronzesmithing phase in the region, possibly through the itinerant smiths who brought their knowledge and skills to these settlements. The other explanatory model is that clay tuyeres were made on the spot or exchanged, but lost their original function and meanings, and that they could demonstrate a sense of belonging or kind of attachment of the post-Neolithic communities from northern Poland to the metal-oriented Únětican *koiné*.

10) Following the typology of the Danubian stone industry developed for Kuyavia, the artefact from Lachmirowice can be assigned to Type 3c (Grygiel 1976) or Type IB3.1322 (Czerniak 1980).

11) There is a formal resemblance between the dagger from Zwierzyniec and the specimen reported from Kromolin near Głogów in Lower Silesia (Gedl 1980, 42 pl. 12, 78; see also Blajer 1990).

12) According to Wüstemann (1995, 34-35 pls 93-96), the dagger from Zwierzyniec represents the Burgstaden-Leubingen subtype of triangular daggers.

13) According to Wels-Weyrauch (2015, 68 pl. 10), the dagger from Łęki Wielkie represents the Baltic-Padanian type.

14) A bronze pin with a round head and twisted body was hoarded in Pszczółki near Gdańsk (woj. pomorskie/PL), and marks the final (= 6th) phase of the ÚC and later stages of the Hurbanovo group (Schubert 1973, 22 pl. 7, 1; Gedl 1983, 31-33 pl. 3, 77; Blajer 1990, 72-73. 127 tab. 66, 3-4; Bokiniec 1995, 91). A dagger found in Kosyń near Olsztyn (woj. warmińsko-mazurskie/PL) also has parallels in the late Hurbanovo metal industry and can be linked to the ÚC or ÚC affiliated, although according to Blajer/Sobieraj/Szpunar (2019, 50-53) the object from Kosyń should be placed in the early MBA.

15) It is now generally assumed that the Únětice region operated as the pick-up zone for fahlore copper to Scandinavia (Vandkilde 2017; 2019, 12), and the recent paper on the LN II hoard from Pile in Scania provides substantial evidence that *Ösenringkupfer* was used in the Nordic zone for local axe industry and that this region was safeguarded with supplies of metal ingots in the form of *Ösenhalsringe* (Nørgaard/Pernicka/Vandkilde 2019, 16).

16) A review of the Úněticean daggers from Poland shows that specimens provided with three rivets coexisted with five-rivet daggers. Similarly, daggers with two-piece handles were contemporary to specimens with a handle cast in one-piece (Sarnowska 1969, 74-75; Gedl 1980, 11-12 pl. 1, 1-2). Uenze (1938, 39-40) claims that these are not chronological differences but indicate different workshops.

17) Currently, Polish archaeology considers four origin areas for the Bell Beaker migrants: (i) northern Germany and Denmark (Czebreszuk 1996), (ii) the Saale-Elbe region (Kośko 1979), (iii) Bohemia and Moravia (Jażdżewski 1937), and recently (iv) the Iberian Peninsula (Wawrusiewicz/Januszek/Manasterski 2015).

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Zusammenfassung / Summary / Résumé

Neue Daten für die Erforschung der frühen Bronzezeit in Nordpolen (2350-1600 BC)

In diesem Beitrag werden im Depot aufbewahrte archäologische Objekte und einige jüngere Streufunde aus dem nördlichen Zentralpolen vorgestellt, die in die frühe Bronzezeit datiert werden können und hauptsächlich aus Lachmirowice in Kujawien stammen, darunter Keramikgefäße und ein Steinwerkzeug, das als Pfeilschaftstrecker identifiziert werden kann. Bei den anderen Artefakten handelt es sich um zwei Tondüsen aus dem Kulmerland und um drei Bronzedolche aus Großpolen und Masowien, die mit der Aunjetitzer Metallindustrie in Verbindung gebracht werden können. Um weiterführende Informationen zu den Objekten zu erhalten, wurden ihre chemische Zusammensetzung sowie die verwendete Technologie bestimmt und diese anschließend mit den stilistischen und technologischen Entwicklungen dieser Epoche kombiniert. Die gewonnenen Ergebnisse erweitern unsere Kenntnisse zur frühen Bronzezeit in Nordpolen und ermöglichen ein besseres Verständnis, wie die lokalen postneolithischen Gemeinschaften in dieser Region in die Glockenbecher- und Aunjetitzer Kultur integriert wurden.

New Data for Research on the Early Bronze Age in Northern Poland (2350-1600 BC)
This paper reports on archived archaeological material and some recent discoveries of stray finds from north-central Poland that can be dated to the Early Bronze Age, mostly from the site of Lachmirowice in the Kuyavia region, including ceramic vessels and a stone tool identified as an arrow shaft straightener. The other objects analysed are two clay tuyeres from Chełmno land (Culm) and three bronze daggers from the region of Greater Poland and Mazovia, which can be connected to the Únětican metal industry. To improve the quality of the information on the artefacts, we determined their chemistry and technology and combined this with the stylistic and technological trajectories of the era. The results obtained add information about the beginnings of the Bronze Age in northern Poland and help to better understand how the local post-Neolithic communities in this region were being integrated within the Bell Beaker and Únětican milieu.

Nouvelles données pour la recherche sur l'âge du Bronze ancien dans le Nord de la Pologne (2350-1600 av. J.-C.)
Cet article traite d'objets archéologiques conservés dans des dépôts et de trouvailles isolées récentes du Centre-Nord de la Pologne, comprenant de la vaisselle en terre cuite et un outil lithique identifié comme redresseur de flèches, datables du Bronze ancien, et pour la plupart originaires de Lachmirowice en Cujavie. Les autres objets sont deux tuyères en terre cuite de la région de Chełmno et trois poignards en bronze provenant de la Grande Pologne et de Mazovie, que l'on peut attribuer à l'industrie du métal únětice. Pour obtenir davantage d'informations sur ces artefacts, on analyse leur composition chimique et la technologie utilisée pour les combiner ensuite à l'évolution stylistique et technologique régionale. Les résultats obtenus enrichissent notre connaissance du début de l'âge du Bronze dans le Nord de la Pologne et permettent de mieux comprendre l'intégration des communautés locales post-néolithiques dans le milieu campaniforme et únětice.
Traduction: Y. Gautier

Schlüsselwörter / Keywords / Mots-clés

Frühe Bronzezeit / Glockenbecherkultur / Aunjetitzer Kultur / Iwno-Kultur / Archäometallurgie / Gebrauchsspurenanalyse
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