The Wrocław–Szczytniki flanged axe from Koperniki A contribution to archaeometallurgical studies on the Únětice axes in Poland

Sekera s lištami typu Wrocław–Szczytniki z lokality Koperniki Příspěvek k archeometalurgickému studiu únětických seker v Polsku

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This work is a contribution to archaeometallurgical studies on the Únětice axes in Poland. The research was initiated by a single find of the Wrocław–Szczytniki flanged axe recovered from the village of Koperniki (Lower Silesia, Poland). The axe was examined in terms of raw–material profile (ED–XRF) as well as its micro-, and macrostructure (OM). The spatial distribution, deposition context, and raw–material profiles of the remaining Únětice axes from Central-Eastern Europe, with a special emphasis put on those recovered from the Polish land, were also juxtaposed throughout this work. It has been established that the axe from Koperniki was cast in standard Sn–bronze alloyed from so-called Eastern Alpine copper, and thus, the axe may be considered as one of the very last Wrocław–Szczytniki specimens emerging in the Odra and Vistula Basins. Although the casting was intensively plastic-worked out, the axe from Koperniki itself was not used in the past. Hence, the statement that the axe was intended to serve as a prestigious or insignia metal object rather than fulfil utilitarian functions seems reasonable. The obtained conclusions indicate that the single wet–findings of the Wrocław–Szczytniki axes (including the specimen from Koperniki) reflect indeed the aquatic hierophanies of single hoards. Furthermore, having analysed the results of the research performed we can state that the raw–material profile of some Únětice axes presents the chronological sensitivity, and thus, confirms their usability for raw-material dating, especially concerning so-called single finds.

Early Bronze Age – Únětice culture – flanged axe – Wrocław–Szczytniki type – archaeometallurgy – metallography

Článek je příspěvkem k archeometalurgickému studiu únětických seker s lištami v Polsku. Výzkum byl iniciován solitérním nálezem sekery s lištami typu Wrocław–Szczytniki učiněným v obci Koperniki (Dolní Slezsko, Polsko). Analýza sekery zahrnovala stanovení jejího prvkového složení (ED-XRF analýza) i posouzení mikro- a makrostruktury (optická mikroskopie). Pozornost byla věnována rovněž prostorové distribuci, nálezovému kontextu a základní materiálové charakterizaci ostatních seker únětické kultury ze středovýchodní Evropy, se zvláštním zřetelem na nálezy z polského území. Bylo prokázáno, že sekera z lokality Koperniki je odlitkem ze standardního cínového bronzu s příměsemi charakteristickými pro tzv. východoalpskou měď. Nález lze proto považovat za jednoho z posledních zástupců seker typu Wrocław–Szczytniki objevujících se v povodí Odry a Visly. Přestože byl odlitek podroben intenzivnímutváření, sama sekera z Kopernik pro práci použita nikdy nebyla. Proto soudíme, že měla sloužit spíše jako symbol prestiže a moci než jako pracovní nástroj. Výsledky výzkumu naznačují, že jednotlivé nálezy seker typu Wrocław–Szczytniki z vodního prostředí (včetně exempláře z lokality Koperniki) skutečně odrážejí hierofanii takového prostředí u jednotlivých depotů. Na základě analýzy výsledků daného průzkumu lze rovněž konstatovat, že základní materiálové charakteristiky některých únětických seker vykazují chronologickou citlivost, což potvrzuje jejich využitelnost pro datování pomocí základní charakterizace materiálu; týká se to především tzv. solitérních nálezů.

starší doba bronzová – únětická kultura – sekera s lištami – archeometallurgie – metalografie

1. Introduction

In the archaeological collection of the District Museum in Nysa a flanged axe (inventory no. MNa/A/749; *fig. 1*) dated to the Bronze Age is stored. As one of the oldest bronze artefacts discovered in the Paczków Foothills area, the axe was found accidentally in 2015. It was recovered from a dry river bed, in a forest near the village of Koperniki, Nysa district, Opole Voivodship, on an upheaval rising to 250 m above sea level.

The village of Koperniki is located in the north–eastern part of the Paczków Foothills, which form the south–eastern part of the Sudety Foothills macroregion (north–eastern margin of the Bohemian Massif; *Kondracki 1965*, 260; *1994*, 159). Paczków Foothills are a narrow plateau (260–280 m above sea level) squeezed among the Otmuchów Depression, the Nysa Ice-marginal Valley, and the Golden Mountains (*Rychlebské hory*). The plateau is built of alluvial cones and under-slope covers lying on the Tertiary clays, covered with Pleistocene deposits, with gravels and sands of kame terraces from the Stadial of the Oder Glaciation among them (*Walczak 1970*, 397–398; *Kondracki 1994*, 162).

2. Settlement analysis

The settlement analysis was based on the results of the Polish Archaeological Record Survey (*Archeologiczne Zdjęcie Polski*, further PARS) and covered the area within the radius of about 15 km from the axe discovery place. Since the axe from Koperniki has a specified chronological attribution, the PARS query results are given in the form of a map (*fig. 2*) with the distribution of the Early Bronze Age (further: EBA) settlement relics, with a special emphasis put on the Únětice culture (further ÚC).

Within the nearest neighbourhood of the axe discovery place, there is the EBA settlement (Burgrabice 6) and two ÚC settlements: Goświnowice 9 and Ligota Wielka 3 (*fig. 2*). At the second site, another Wrocław–Szczytniki axe was found (*Altschlesien 1924*, 68, Abb. 23; *Szpunar 1987*, 32, Taf. 9: 175). Although these relics prove the incidental character of the ÚC settlement in the north–eastern part of the Paczków Foothills, they still confirm the chronological and cultural attribution of the axe from Koperniki and allow its connection with the Lower Silesian ÚC communities.

3. Typological analysis

The axe from Koperniki was arranged in a profiled form with a distinctly shaped cutting edge and rounded, asymmetrical butt–end (*fig. 3*). The flanges run a slightly curved course and approach each other in the middle part of the axe. The trough (*Bahn*) is flat and, in its central part, there is a slightly visible rise (see *fig. 1*). In the side view, the axis of symmetry is straight. The lateral sides are gently faceted. The top and bottom sides are slightly convex and narrow towards the cutting edge which was originally symmetrical and fan–shaped with a gently marked transition to the axe body. The metric features of the axe are following: length: 5.8 cm; cutting edge width: 2.0 cm; thickness: 0.6 cm; height of the flanges: 0.2 cm; weight: 24 g.

Fig. 1. Koperniki, Nysa district. The flanged axe.
Obr. 1. Koperniki, okr. Nysa. Sekera s lištami.

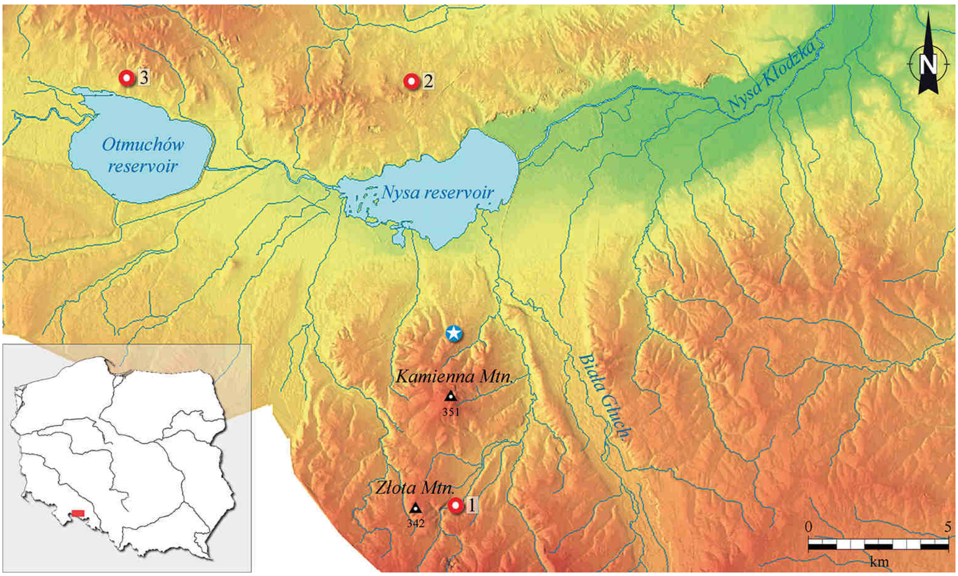

Fig. 2. Place of the axe from Koperniki discovery against the EBA settlement in the Paczków Foothills area (PARS data: WUOZ Opole). ✪ – place of the discovery ⭘ – ÚC (Únětice culture)/EBA (Early Bronze Age) sites. Sites: 1 – Burgrabice, gm. Głuchołazy, site 6, EBA settlement: 11 potsherds; 2 – Goświnowice, gm. Nysa, site 9, settlement point: 6 ÚC potsherds; 3 – Ligota Wielka, gm. Otmuchów, site 3, ÚC settlement trace: the Wrocław–Szczytniki axe.
Obr. 2. Místo nálezu – Koperniki – ve vztahu k osídlení ze starší doby bronzové v Paczkowské hornatině (PARS data: WUOZ Opole). ✪ – místo nálezu ⭘ – lokality únětické kultury/starší doby bronzové. Lokality: 1 – Burgrabice, Głuchołazy, lokalita 6, sídliště: 11 střepů; 2 – Goświnowice, Nysa, lokalita 9, 6 střepů; 3 – Ligota Wielka, Otmuchów, lokalita 3, sekera typu Wrocław–Szczytniki.

According to A. Szpunar, the flanged axes can be divided into three categories: axes with a (I) waisted shape, (II) parallelsided–curved shape, and (III) trapezoidal shape. A distinctive feature of this proposal is a manner in which the flanges were shaped (*Szpunar 1987*, 7). The axe from Koperniki belongs to the first group. A further classification allows it to be placed within the Wrocław–Szczytniki type (further W–Sz), known also as the Únětice type. Adopting the criteria concerning the butt–end shape, A. Szpunar distinguished four subtypes (A–D) of the W–Sz axes (*fig. 4*; *Szpunar 1987*, 20–35; *Blajer 1990*, 19). In terms of this proposal, the axe from Koperniki may be classified as the A subtype.[1] The distinctive

[1] According to *J. Říhovský* (*1992*, 83–84, Taf. 13: 173–176), the axe from Koperniki may be classified as the D subtype of the 4b type, singled out from the IV group. According to *H. Vandkilde* (*1996*, 61–80), the axe from

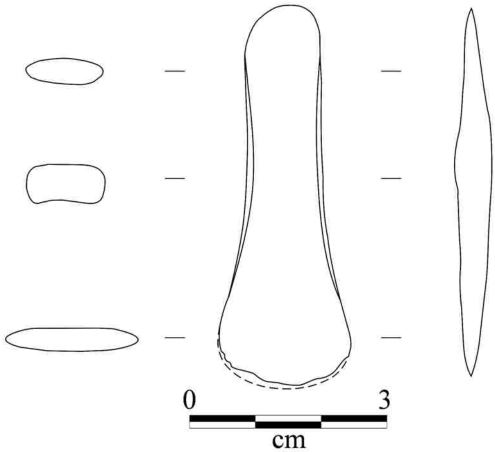

Fig. 3. Koperniki, Nysa district. The flanged axe.
Obr. 3. Koperniki, okr. Nysa. Sekera s lištami.

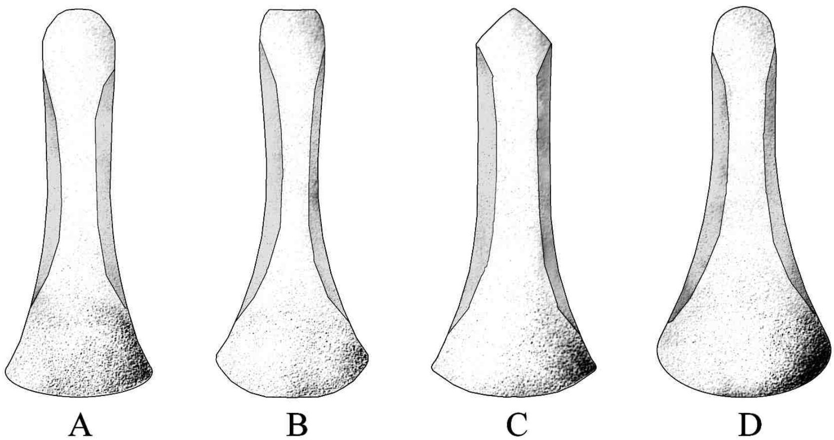

Fig. 4. Typological series of the Wrocław–Szczytniki type axes.
Obr. 4. Typologická řada seker typu Wrocław–Szczytniki.

features of such a subtype are (1) rounded butt–end, (2) slightly waisted flanges, (3) a clearly distinguishable, simple or fan–shaped cutting edge (*Szpunar 1987*, 20). The metric features of the W–Sz A type fall within the ranges: (1) length: 7.1–16 cm, (2) cutting edge width: 2.7–3 cm, (3) flange height: 0.10–0.25 cm, (4) weight: 85–405 g. The axe from Koperniki is the smallest representative of the Únětice type axes found in Poland.

Up till now, over 140 specimens of the W–Sz axes found on the Polish land have been reported, 80 of which belonging to the A subtype (*Szpunar 1987*, 20–35; *Blajer 1990*, 21), which is the most abundant group (*fig. 5*). Since collective hoards with long metal series usually include all subtypes of the W–Sz axes (*Blajer 1990*, 19), chronological and spatial sensitivity of their typological series is distinctively limited.

Koperniki represents the A5 type (= Store–Heddinge type), distinguished as a waisted type from the A class (= primitive low–flanged axes).

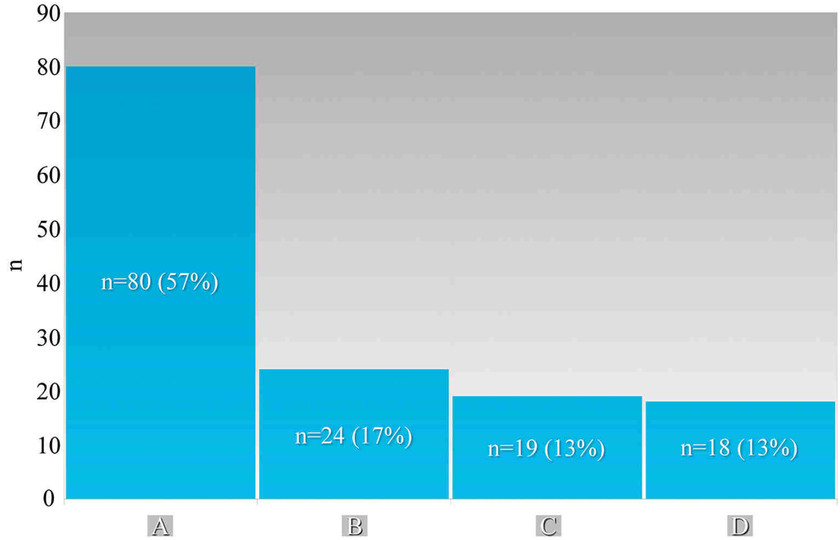

Fig. 5. Frequencies of the Wrocław–Szczytniki type axes (*Szpunar 1987*, 20–35; *Blajer 1990*, 21, adapted). For A–D, see *fig. 4*.
Obr. 5. Četnosti seker typu Wrocław–Szczytniki. K označení A–D viz *obr. 4*.

The W–Sz A type axes were recorded primarily as a part of the collective hoards or single finds. However, there are also specimens recognized as grave offerings (*Sarnowska 1969*, 63; *Szpunar 1987*, 20–24; *Blajer 2001*, 76–78). The axes of this subtype were distributed prevalently in north–western Poland, with particularly high concentration in (1) Middle Silesia and the areas south from Wrocław, (2) Western Pomerania, (3) the Middle and Upper Warta and Oder Basins (4) the Upper Noteć Basin (*fig. 6*; *Szpunar 1987*, 28–29). Axes resembling the W–Sz type are abundant in the southern and western areas of the Oder Basin, including the Upper Danube Basin[2] (*Sarnowska 1969*, 63–64; *Novotná 1970*, 33–37, Taf. 9–10; *Mayer 1977*, 77–84, Taf. 16–17; *Szpunar 1987*, 35; *Blajer 1990*, 21; *Říhovský 1992*, 76–108, Taf. 12–17; *Moucha 2007*, 65–67, Abb. 18; *Chvojka – Červenka 2008*; *Praumová – Šteffl 2013*; *Praumová et al. 2014*; *Šteffl – Krásný 2016*).

The area of dense distribution of the W–Sz A axes overlaps with the spatial extent of the ÚC in the phase of its full development (i.e. 5th phase, according to V. Moucha) together with its satellite groups (Iwno culture, Nowa Cerekwia group, Płonia group; *Moucha 1963*; *2007*; *Szpunar 1987*, 28–29; *Blajer 2001*, 76–78), which allows the establishment of their time–usage to the 2nd half of the EBA (= B A1b–2), with a possible transition to the B B1

[2] Outside the territory of Poland, the W–Sz axes are referred to as the Saxon, or in general, to the Únětice type. A formal resemblance to these axes is also seen in some types of the Neyruz and Salez axes (*Mayer 1977*, 71–78, Taf. 16–17). It seems that the typological indicators proposed by *A. Szpunar* (*1987*, 20–35, Taf. 5–10: 84–205) for the W–Sz axes are far more flexible, and thus, the typological sensitivity of this group has been significantly reduced against the backdrop of the Central European findings. Consequently, it poses problems for conducting comparative studies. Hence, it would be reasonable to revise the EBA axes from the Polish land, with respect to the typological criteria proposed by e.g. Czech (*Říhovský 1992*, 76–108, Taf. 12–17; *Moucha 2007*, 66–67, Abb. 18) or Danish (*Vandkilde 1996*, 61–138) academics.

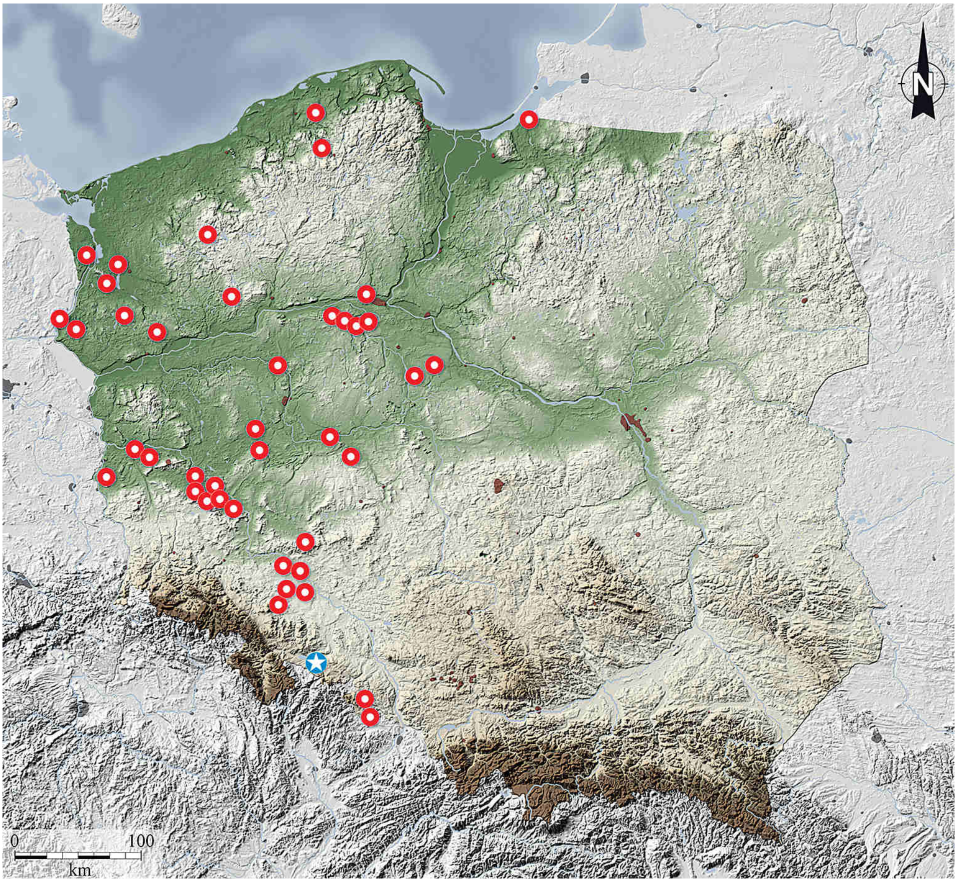

Fig. 6. Distribution of the Wrocław–Szczytniki A type axes on the Polish land (*Szpunar 1987*, 143–144, adapted; map background: AridOcean/Shutterstock.com). ✪ – the axe from Koperniki ⭘ – other axes.
Obr. 6. Distribuce seker typu Wrocław–Szczytniki A na polském území (*Szpunar 1987*, 143–144, upraveno; mapový podklad: AridOcean/Shutterstock.com). ✪ – sekera z lokality Koperniki ⭘ – ostatní sekery.

phase (*fig. 7*). Therefore, in north–western Poland, the W–Sz A axes can be dated from 1950 BC to 1700/1600 BC and arbitrarily connected with the Głogów horizon (*Blajer – Szpunar 1981*, 300–301; *Szpunar 1987*, 24–29; *Blajer 1990*, 19, 83–85; *Vandkilde 1996*, 141).

4. Metallographic analyses

The metallographic investigations involved the employment of the spectral measurements (ED–XRF) and the surface analyses concerning micro- and macrostructure (OM). Based on the metallographic data, the raw–material profile and the axe manufacturing technique were implemented in this study as well.

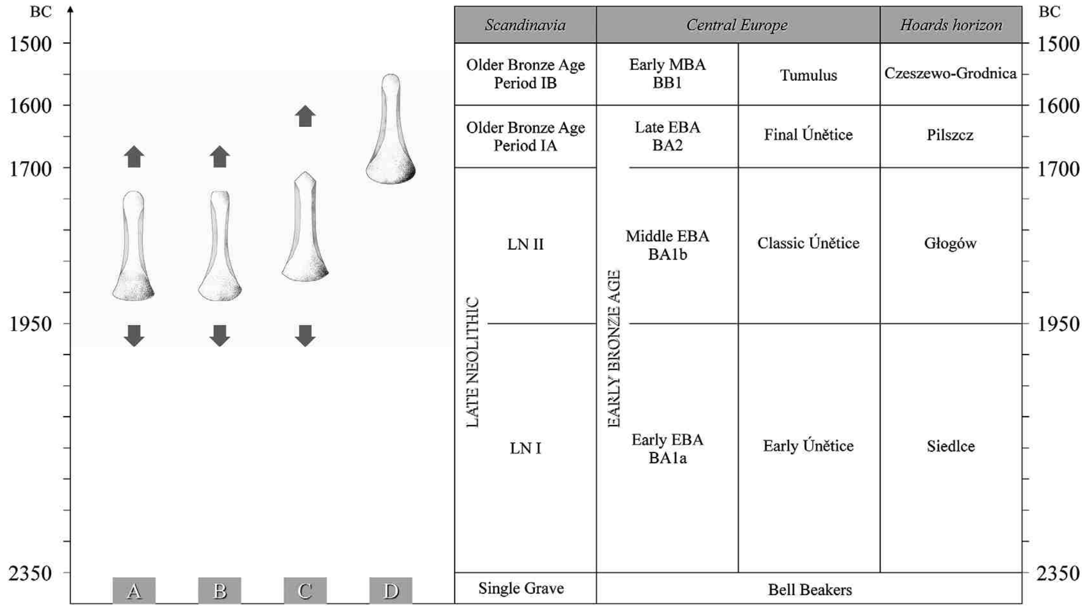

Fig. 7. Chronology of the Wrocław–Szczytniki type axes (*Blajer – Szpunar 1981*; *Szpunar 1987*, 20–35, Taf. 57; *Blajer 1990*, 19–21; *Vandkilde 1996*, 139–143, fig. 134).
Obr. 7. Chronologie seker typu Wrocław–Szczytniki.

4.1. Raw–material analysis (ED–XRF)

The raw–material characteristics of the axe involving its copper and alloy profile was determined on the basis of a series of three measurements taken from the metallic core of the axe in three microareas: (1) cutting edge, (2) flange and (3) butt–end (*tab. 1*). This study was accomplished by the performance of an analysis based on the X–ray fluorescence spectrometry with the energy dispersive X–ray fluorescence (ED–XRF) Spectro Midex spectrometer equipped with a molybdenum X–ray lamp of the 44.6 kV excitation energy and a Si Drift Detector (SDD) of the 150eV resolution.

The alloy profiles of the analytical microareas seem convergent. However, some differences become visible here when considering the weight fractions of arsenic (As), antimony (Sb), tin (Sn), and lead (Pb) (*tab. 1*; *fig. 8*). This could result from a limited solubility of Sn and Pb in copper (Cu) and their propensity for dendritic segregation. In the case of As and Sb, the differences in their distribution were caused by the phenomenon of reversed segregation (*Bugoi et al. 2013*, 1240).

These phenomena result from the crystallization dynamics of copper alloys (disequilibrium crystallization). A hindered progress of diffusion processes resulted in the elemental segregation in different parts throughout the volume of the casting (*Romankiewicz 1995*, 136–143). A vertical temperature gradient associated with the casting solidification was the cause of the alloy impurities (As, Sb, Pb) fractioning. The highest concentration of impurities was recorded in those axe parts which solidified last (the trough and butt-end), located in the vicinity of the gating system (*Romankiewicz 1995*, 143–151). An increased Sn

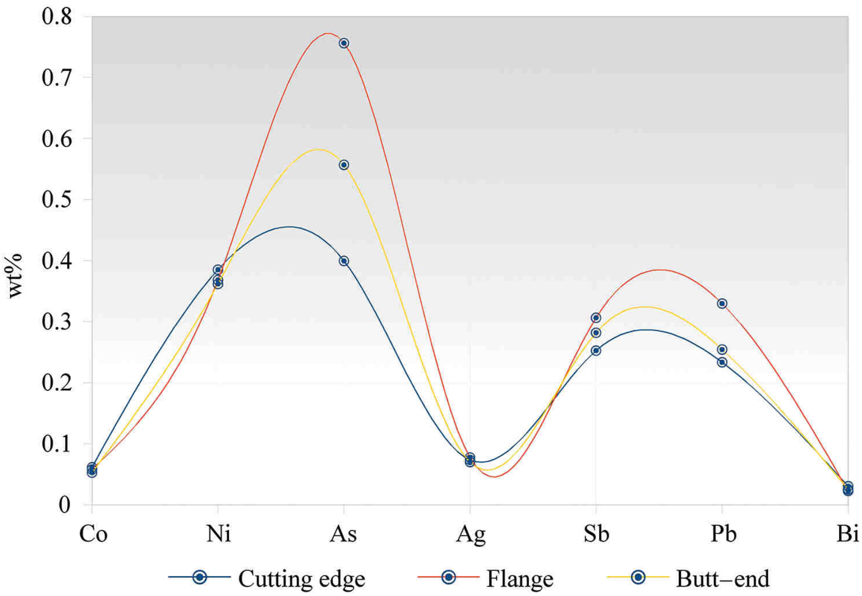

Fig. 8. Distribution of alloy impurities in the axe from Koperniki.
Obr. 8. Distribuce vměstků ve slitině sekery z lokality Koperniki.

and Pb content in the trough was caused by the phenomenon of volumetric shrinkage in the middle part of the casting. The gap between the mould and the casting where Sn–Cu and Cu–Pb eutectic mixtures were translocated by metallostatic pressure is likely to have been responsible for the intensification of the Sn and Pb segregation phenomenon (*Beckerman 2008*, 349–350).

The presence of mercury (Hg) was not detected in the raw-material profile of the axe. The absence of this element together with an increased cobalt (Co) and nickel (Ni) content suggests that the axe was cast from re-melted copper ores (*Pernicka et al. 1997*, 124). The average iron (Fe) content does not exceed 1 wt%, which is typical of artefacts dated to the Eneolithic and Early Bronze Age (*Cook – Aschenbrenner 1975*, 253). The alloy profile of the axe is complemented by tin (Sn) making up to 10 wt%. The obtained results allow the conclusion that the axe from Koperniki was cast in the 6 class of Sn–bronze, according to *H. Vandkilde* (*1996*, 30).

The copper profile of the axe refers to tetrahedrite Ib class (*Fahlerzmetalle*) with nickel, commonly known as Eastern Alpine copper, and it qualitatively matches with the III type (As>Ni>Sb>Ag; *Krause 2003*, 90, 333, Abb. 40). Moreover, a homology relationship can be noticed between the axe profile and the Kläden copper (Ni/As>Sb>Ag; *Rassmann 2010a*, 814, Tab. 1; *2010b*, 712, Abb. 1). The copper profile of the axe refers also to the copper of group 3 (As–Sb–Ag–Ni), proposed by *H. Vandkilde* (*1996*, 30–31, fig. 2–3). This allows ascribing the axe from Koperniki to the IV metallurgical horizon (further: MH) of the Early Bronze Age (1850/1800–1600 BC). The assumed dating can be chronologically correlated with the Głogów–Pilszcz horizon (*Krause 2003*, 83–85, Abb. 34; *Rassmann 2010a*, 809, 812, Abb. 1, 4; *2010b*, 712, Abb. 1).

Part	Fe	Co	Ni	Cu	As	Ag	Sn	Sb	Pb	Bi
Cutting edge	<0.025	0.061	0.39	90	0.40	0.073	8.7	0.25	0.23	0.031
Flange	<0.025	0.058	0.37	87	0.76	0.078	11	0.31	0.33	0.023
Butt–end	<0.025	0.053	0.36	89	0.56	0.070	9.5	0.28	0.25	0.025
Mean	<0.025	0.06	0.4	89	0.6	0.07	10	0.3	0.3	0.03
RSD [%]	...	8	3	2	31	5	12	10	19	15

Tab. 1. The elemental composition of the axe (wt%) with corresponding values of the relative standard deviation (RSD).
Tab. 1. Prvkové složení seker (v hm.%) s odpovídajícími hodnotami korelačních koeficientů.

4.2. Microstructure analysis (OM)

The microstructure analysis was performed with the use of the Nikon Eclipse LV150 metallographic microscope (OM) equipped with the Nikon Digital Sight DsFi1 microscopic camera and the Nis–Elements system for picture analysis. The observations were conducted in the trough part which was polished with diamond paste (1 μm), and etched in HCl (30 ml) + $FeCl_3$ (30 g) in C_2H_5OH (120 ml) solution. The obtained results enabled the determination of the axe from Koperniki manufacturing technology.

In the axe microstructure, strongly deformed grains with highly blurred boundaries (*fig. 10a–b*) are noticeable. Their characteristic shape is indicative of the plastic working implementation by the Bronze Age metalworker. The presence of the so-called twins locked in the microstructures (*fig. 10: a–c*) suggests that the axe could have been reforged hot, or, which is more probable, it was plastic–worked out by cold forging and annealing (*Kienlin 2011*, 134). This sequence refers especially to the stage of raising the flanges of the axe. These observations may be confirmed by the fact that the eutectic mixture of $\alpha+\delta$ present in the microstructure at the Sn=10 wt% content strongly limited the possibilities of cold plastic working. Due to this fact, further processing of the casting required annealing treatment in order to obtain a homogenized microstructure (*Scott 1991*, 11–29).

The microstructure features prove that the narrow face of the axe was intensively plastic-worked out which in fact diminishes the possibility of implementing the lost–wax technique (*cire perdue*) by the Bronze Age metalworkers.[3] However, it cannot be ruled out that the final form of the flanged axes was obtained at the plastic working stage, while casting itself was performed in the lost–wax technique. This hypothesis can be confirmed by the lack (?) of split–moulds for axe casting from the area occupied by the EBA communities. Nevertheless, the employment of the split–moulds has already been confirmed as it can be proved by e.g. the stone mould for casting band ornaments recovered from the defensive settlement in Bruszczewo (*Jaeger – Czebreszuk 2010*, 223; *Silska 2012*, 115–121, ryc. 79). The casting seams commonly occurring on the Únětice double axes (*Aunjetitzer Doppeläxte*), including also finds from the Polish land (*Gedl 2004*, 29–30, Taf. 18: 28–33) may be considered as an indirect support for mastering this technique.

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[3] The observations made by *A. Szpunar* (*1987*, 20–35) are interesting in this context. Analyzing the W–Sz axes from the Polish land, he ascertained that none of them bears traces left by casting seams.

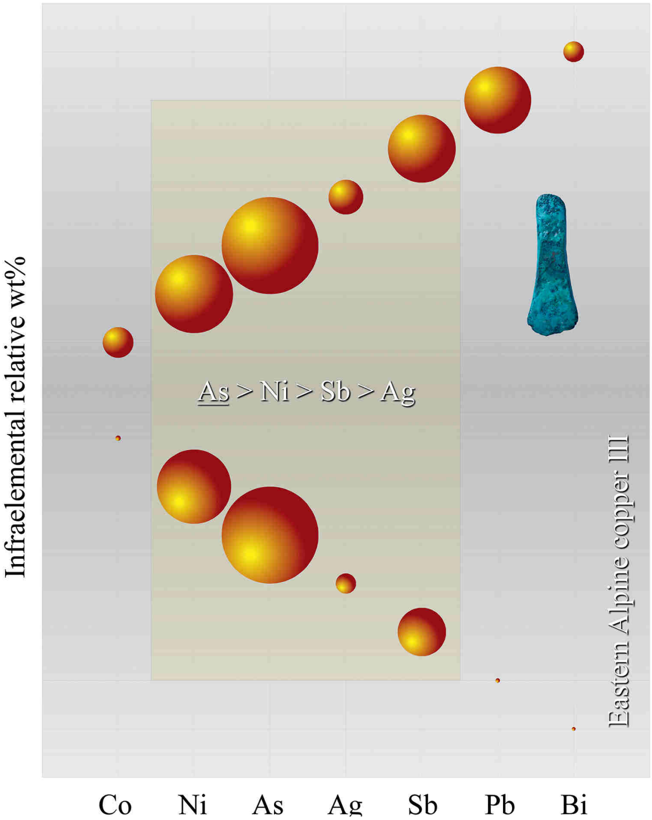

Fig. 9. The copper profile of the axe from Koperniki (*Krause 2003*, 333, adapted).
Obr. 9. Základní charakterizace mědi sekery z Koperniki.

4.3. Macrostructure analysis (OM)

The macrostructure analysis was performed with the use of the Nikon SMZ 745Z stereoscopic microscope equipped with the Nikon Digital Sight DsFi1 microscopic camera and the Nis–Elements BR system for picture analysis. The observations were conducted with respect to the quality and state of preservation of the casting surface. The obtained results enabled the determination of the axe from Koperniki manufacturing technology.

Although the casting seams were not identified on the axe surface[4] (*fig. 11: c–d*), the use of the split-mould can be indicated by the presence of the so-called drafts discernible on the both sides of the axe. What is suggestive, the drafts are proved to have enabled knocking the casting out of the mould (*fig. 11: b–d*).

In the butt–end, an agglomeration of casting pores, which tend to cummulate near the gating system (*fig. 11: a–b*) was observed. Sn–bronze used for casting the axe shows an exceptionally low casting shrinkage. However, a significant difference between the beginning and the end of solidification made it impossible for the Bronze Age metalworker to

[4] The lack of a casting seam does not have to be distinctive for the castings worked with the lost-wax technique. Skillfully shaped (matched) parts of the mould can effectively prevent its creation. Casting seams may also be removed at the stage of finishing.

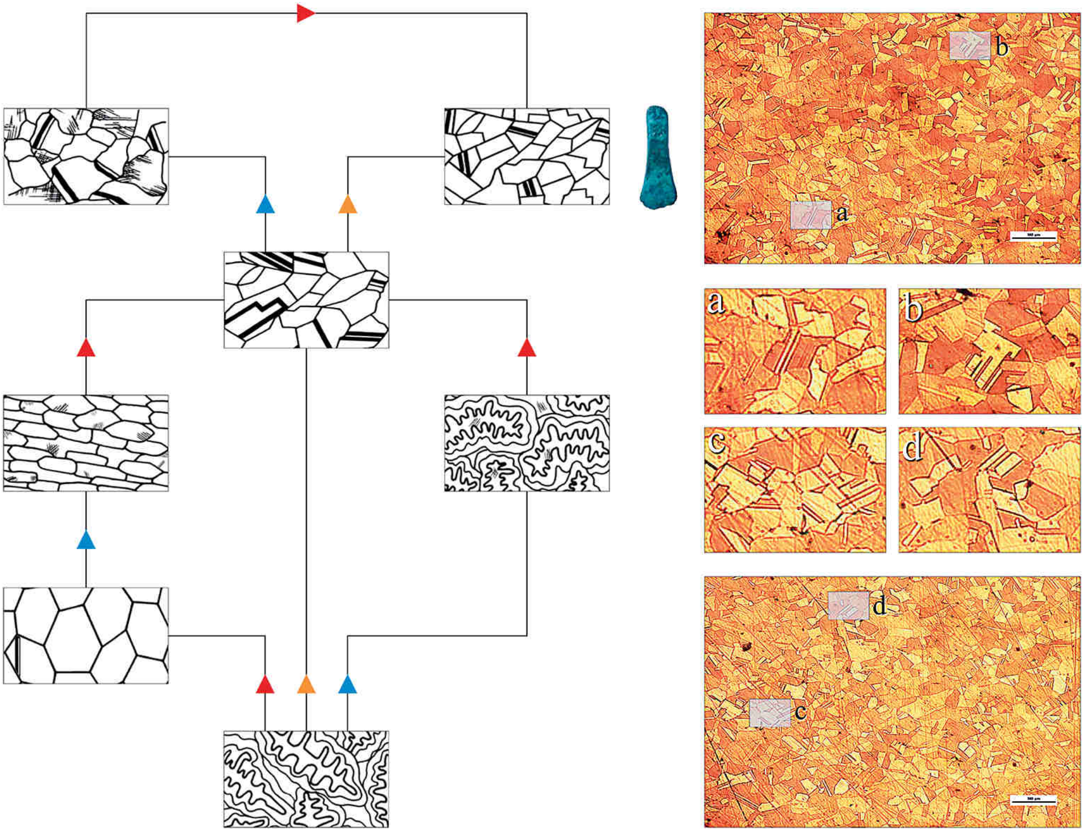

Fig. 10. *Chaîne opératoire* of plastic working of copper and bronze castings compared with the axe from Koperniki microstructures (*Kienlin 2008*, 96, fig. 15, adapted). ► – cold forging ► – hot forging ► – annealing.
Obr. 10. *Chaîne opératoire* tváření měděných a bronzových odlitků v porovnání s mikrostrukturou sekery z lokality Koperniki. ► – tváření za studena ► – tváření za tepla ► – žíhání.

obtain a cast of good compactness. A shrinkage phenomenon accompanying the solidification of the casting did not result in a shrinkage cavity.[5] Nevertheless, it initiated shrinkage porosity, which was manifested as micro–shrinkages and pores (*Adamski et al. 1956*, 14–107). Their visible concentration in the butt–end confirms the employment of the standing–mould.[6] All these can lead to a conclusion that the axe from Koperniki was cast into an upright standing split-mould, and the stream of molten metal passed directly to the gating system which was next cut off from the butt-end part (*fig. 12*; *Kienlin 2011*, 129).

[5] There are known examples of the Únětice axes from the Polish land with shrinkage cavities registered in butt-end parts. The axe from Lubków, Wrocław–Szczytniki, or Deszczno can be mentioned here (*Szpunar 1987*, 30–32, Taf. 9: 156, 167, 172).

[6] Technological aspects regarding the EBA casting praxis were raised, i.a. by T. L. Kienlin. Referring to the metallographic analysis results and the common occurrence of shrinkage porosity in butt-end parts of the EBA axes, he pointed out (*Kienlin 2011*, 129) that all specimen of this type were cast into upright standing-moulds.

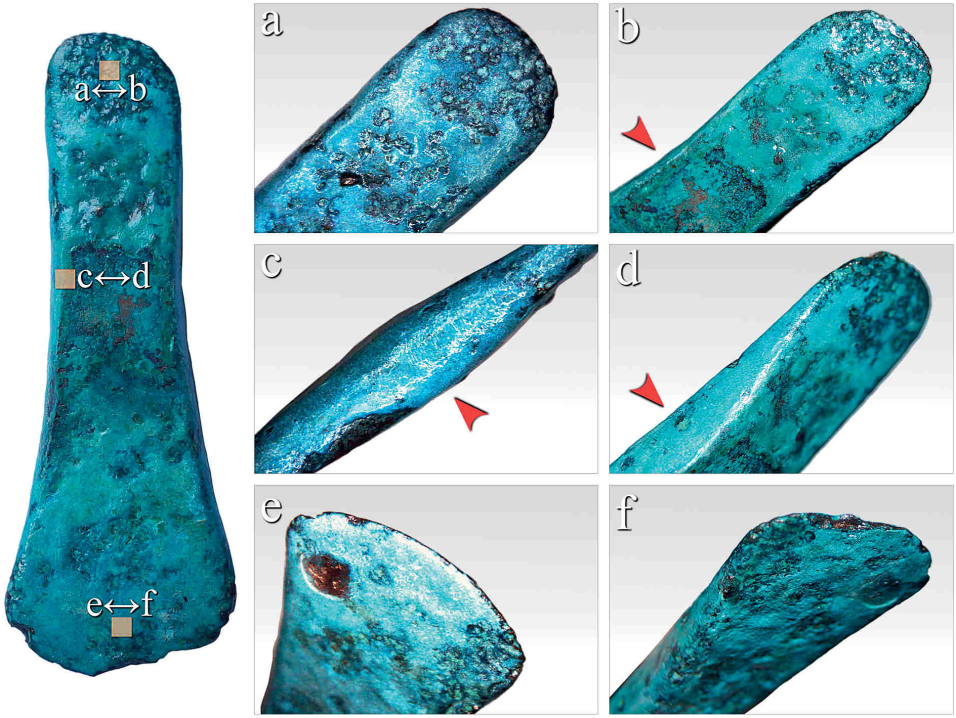

Fig. 11. Macrostructures of the axe from Koperniki: (a) casting pores; (b) traces of plastic shaping of the narrow face; (c, d) traces of faceting of the sides; (e, f) cutting edge deformation.
Obr. 11. Makrostruktura sekery z lokality Koperniki: (a) póry ve slitině; (b) stopy plastického tváření úzkého čela; (c, d) stopy fazetování stran; (e, f) deformace břitu.

Some deformations were recognized on the surface of the axe, which could suggest its employment in the Bronze Age. They are visible in the form of the cutting edge nicks (*fig. 11: e–f*). However, as the surface of the axe is significantly degenerated, the character of these damages should not necessarily be connected with the usage (cutting or chopping), but rather with corrosion. Presumably, a non-utilitarian character of the axe from Koperniki is in a good correspondence with the trend mentioned by *W. Blajer* (*2001*, 265) who claims that the use-wear and re-sharpening traces left on the EBA primitive low-flanged axes from the Polish land are extremely difficult to notice. This suggests, at least partially, a non-utilitarian character of these artefacts. It seems reliable that this trend reflects a phenomenon of the so-called metal fascination, giving rise to the cultural behavior where the very fact of owning metal artefacts was in fact valorized higher than a mere possibility of their practical usage (*Blajer 2001*, 305).

5. Discussion

Up till now, the axe from Koperniki has remained the smallest known representative of the W–Sz axes reported from the Vistula and Oder Basins. This artefact does not follow the

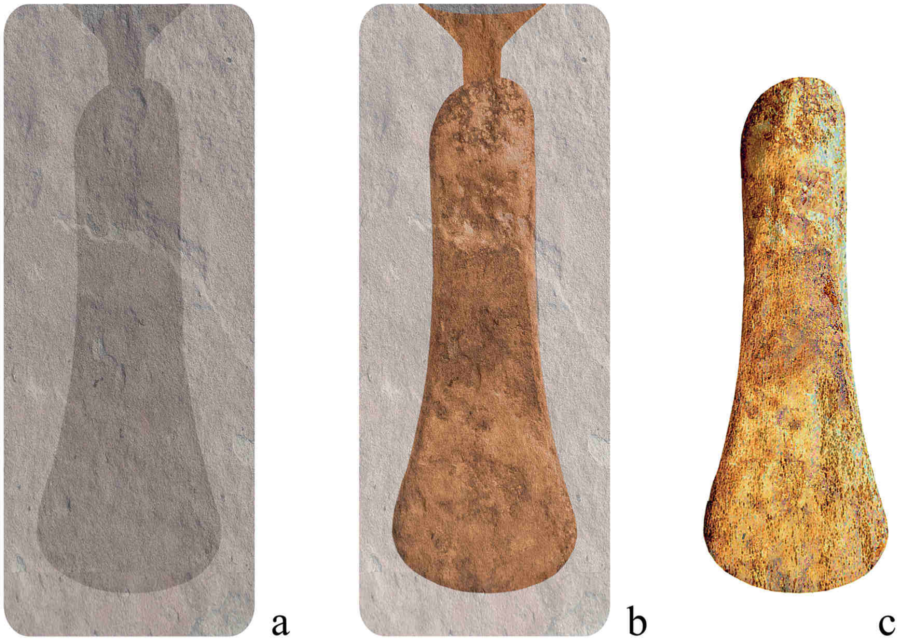

Fig. 12. Hypothetical placement of the casting in a split-mould.
Obr. 12. Hypotetická pozice odlitku v dvoudílné licí formě.

metric trend observed for the Únětice axes from the Lower and Middle Silesia (*fig. 13*). However, the miniaturization of the axe from Koperniki is not a single case, since there is another such flanged axe (also representing the W–Sz A type) found in Włodzień, near Branice[7] (*Szpunar 1987*, 23, Taf. 7: 125). These both axes share the same discovery context as single finds, and thus, limit the chronological potential of this phenomenon. However, it cannot be rejected that the miniaturization of the W–Sz axes bears some chronological sensitivity. Nevertheless, at the present state of knowledge, it should rather be considered as a random phenomenon.

Taking into account the collective finds in the backdrop of the hoarding praxis existent during the EBA and EBA/MBA, then 9 (11 %) and 3 (25 %) of such, respectively, may be treated as aquatic collective hoards[8] (*fig. 14*; *Blajer 2001*, 60). Neither of them contained axes of the W–Sz type.[9] The only case that could confirm that character is a supposed hoard of two W–Sz axes (A and B type) from Piasek near Cedynia, recovered during dredging the Oder (*Szpunar 1987*, 22–30, Taf. 6: 108A, Taf. 9: 160A; *Blajer 1990*, 124; *2001*, 316).

[7] There are also other Central European examples of the EBA axes miniaturization, e.g. the Lausanne I axe from Lanžhot (*Říhovský 1992*, 95, Taf. 15: 216) or the Neyruz axe from Košice (*Novotná 1970*, 35, Taf. 10: 189).

[8] When accepting that the finds from Brzeźno Wielkie, Kromolino, and Przysieka Polska are indeed unrecognized graves (*Blajer 2001*, 78), then frequencies of the W–Sz axes deposition context in collective hoards and graves needs to be reviewed, appropriately to n=10 (7 %) and n=72 (51 %).

[9] In aquatic collective hoards from Smogolice and Steklno dated to the EBA/MBA (multiple finds of Czeszewo type), there were deposited i.a. the Grodnica and Guzowice axes (*Blajer 2001*, 318–321).

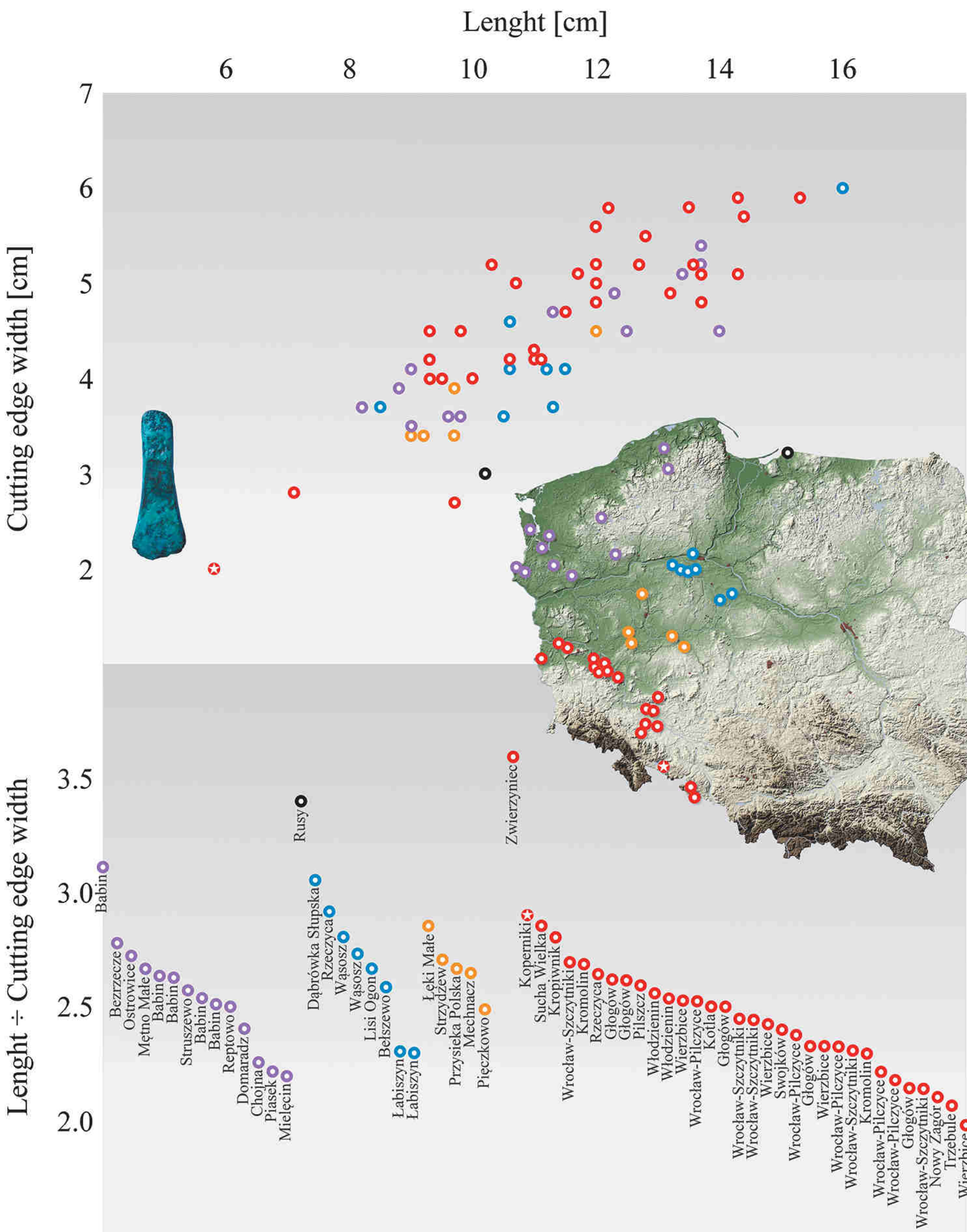

Fig. 13. Metric trends of the Wrocław–Szczytniki type axes from the Polish land (*Szpunar 1987*, 20–35, adapted).
Obr. 13. Metrické tendence seker typu Wrocław–Szczytniki z území Polska.

If these two axes were indeed deposited together, then the hoard (one-type hoard) from Piasek might be the only example of a collective aquatic hierophany of the W–Sz axes.

The lack of the Únětice axes in aquatic hoards perhaps results from cultural sanctions which regulated the hoarding praxis (*Harding 2000*, 352–368). The existence of such cultural directives is already recognized among the EBA communities from the Polish land and can be justified by e.g. the deposition of the willow–leaf ornaments, almost exclusively, in collective hoards or the presence of stone axes or shaft–hole axes registered in a few collective findings[10] (Kromolin, Renice, Żnin; *Blajer 2001*, 261–263).

From among 45 single finds of the W–Sz axes reported from the Polish land[11], 9 specimens deposition context is connected with wet environment[12] (*fig. 14*). Apart from random events which are not generally subject to archeological verification (e.g. losing or abandoning an object), a conclusion that the wet–findings of the W–Sz axes (including the specimen from Koperniki) actually reflect the aquatic hierophanies of single hoards[13] can be drawn. If, indeed, such an interpretation is reliable then it would signal a necessity to formulate another rule associated with the EBA metal hoarding praxis. This rule could sanction the single aquatic deposition of the W–Sz axes, and therefore, it might reflect the phenomenon of taboozating certain metal configurations during aquatic hoarding.

Attempts to find a more precise chronological placement of the axe from Koperniki meet serious obstacles. The typological analysis results point to a wide chronological range (1950–1700/1600 BC). Similar conclusions may be drawn on the basis of the settlement analysis. Since potsherds collected from Burgrabice and Goświnowice sites lack distinctive features (see chapter 2), a chronology more precise than the EBA cannot be determined. However, notwithstanding the foregoing, there are certain premises which can narrow the chronological determination of the manufacturing act of the axe from Koperniki. Here, it appears that technological aspects, especially those regarding the copper and alloy profiles, may prove essential in solving the problem mentioned above.

From among 30 W–Sz axes examined in terms of their alloy profile (making up about 20 % of the total population of over 140 specimens), only in 26 % of them the amount of Sn detected content may be considered as a deliberate (Sn>1 wt%) alloy component (*fig. 15*). Apart from the axe from Koperniki, only in two cases (n=6%) the Sn content oscillates around the value of 5 wt%.[14] A similar distribution of the alloy groups is recorded for the

[10] This behaviour can be seen as legitimizing a high social rank of a person or a group performing the deposition act by referring to burial tradition of the Corded Ware culture elites (*Blajer 2001*, 262). Analogous manifestation has also been recognized in the case of the Trzciniec communities during their expansion to the area of Little Poland. It took a form of erecting burial mounds in places where earlier the Corded Ware culture barrows were concentrated, which was to justify the Trzciniec succession onto the area occupied so far by the Mierzanowice communities (*Makarowicz 2013*, 52–53).

[11] From the Polish land there is known one more EBA single find of axe with possible aquatic deposition. This is, Brusy type axe from Busówno found in 1949 during digging peat. Because of its probable Mierzanowice culture attribution this axe was not included in this summary (*Kostrzewski 1962*, 28; *Szpunar 1987*, 18, Taf. 4: 64).

[12] Due to unspecified find context, 14 axes of the W–Sz type were not included in this summary (see *fig. 14*).

[13] In extensive monographies concerning the metal hoards from the Polish land, *W. Blajer* (e.g. *1990*; *2001*) accepted the definition of hoard as referring to the collective hoards. A broader understanding of this category allows it to include also single finds (e.g. *Harding 2000*, 352–353).

[14] Some reservations can be caused by A. Szpunar proposal to classify the axe from Rusy as the W–Sz B type (*Szpunar 1987*, 22, Taf. 6: 112), since its formal features quite distinctly point to the axes of Żołędowo type,

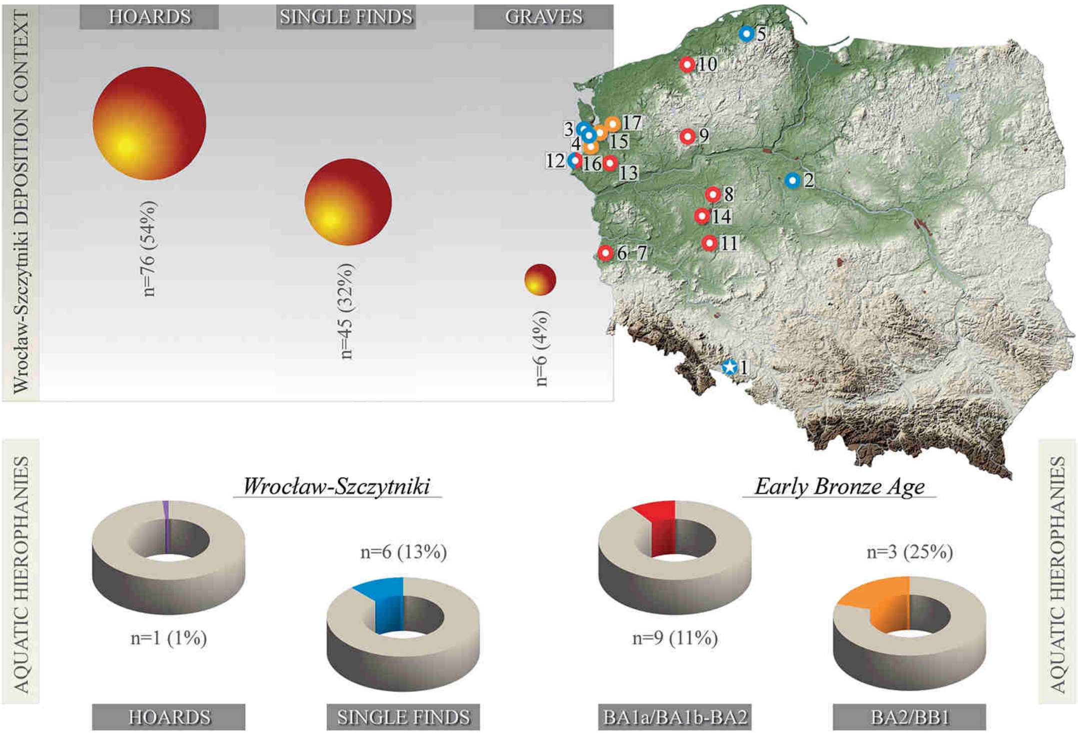

Fig. 14. Aquatic hierophanies of the collective hoards and Wrocław–Szczytniki type axes from the Polish land during the EBA and EBA/MBA against deposition context of the Wrocław–Szczytniki axes (*Szpunar 1987*, 20–35; *Blajer 1990*, 19–21, 97–150; *2001*, 314–321, adapted). ✪ – the axe from Koperniki ○ – the remaining axes ○ – the EBA collective hoards ○ – the EBA/MBA collective hoards.
Obr. 14. Vodní hierofanie hromadných depotů a seker typu Wrocław–Szczytniki z území Polska ze starší a z přechodu starší a střední doby bronzové vs. depoziční kontext seker typu Wrocław–Szczytniki. ✪ – sekera z Koperniki ○ – ostatní sekery ○ – hromadné depoty starší doby bronzové ○ – hromadné depoty z přelomu starší a střední doby bronzové.
1 – Koperniki, gm. Nysa; 2 – Miłachowo, gm. Topólka; 3 – Moczyły, gm. Kołbaskowo; 4 – nearby Gryfin; 5 – Redkowice, gm. Lębork; 6, 7 – Biecz, gm. Brody; 8 – Biedrusko Tworkowo, gm. Suchy Las; 9 – Dobra, gm. Dobra; 10 – Kościernica, gm. Polanów; 11 – Nowy Dwór, gm. Krzywiń; 12 – Piasek, gm. Cedynia; 13 – Renice, gm. Myślibórz; 14 – Stęszew, gm. Stęszew; 15 – Binowo, gm. Stare Czarnowo; 16 – Steklno, gm. Gryfino; 17 – Smogolice, gm. Stargard.

W–Sz axes from the Czech Republic (*fig. 16*), although the contribution of the specimens with the Sn content greater than 5 wt% is slightly higher in this case.

The frequencies of Sn content in the EBA metal artefacts from the Polish land, including the W–Sz axes, resemble the alloy sequences that have been registered in Central and Northern Europe (*fig. 17*). Metal finds from the cemeteries of the Nitra group and Gemeinlebarn

especially to the specimen from Glinica (*Szpunar 1987*, 39, Taf. 12: 226). The axe W–Sz axe from collective hoard from Głogów, included in the compilation presented in *fig. 15*, represents A or D types. The only description available in the *Stuttgarter Metallanalysendatenbank* refers only to *Axt mit Nackenscheibe* (*Sarnowska 1969*, 340–343, ryc. 155: s–ż; *Krause 2003*, CD–ROM: SAM: 8946).

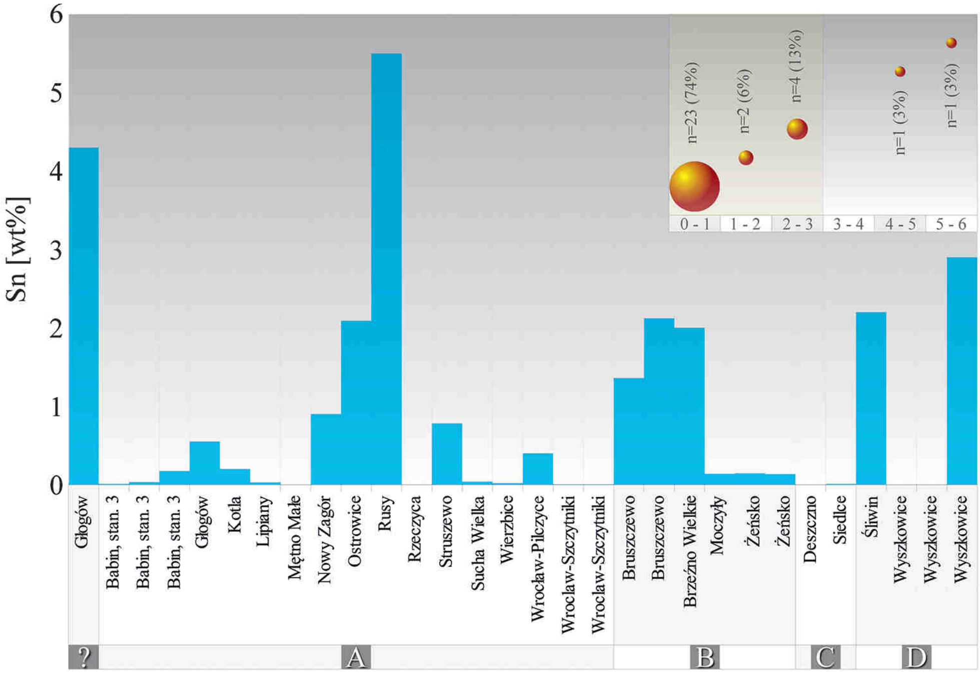

Fig. 15. The Sn distribution in the Wrocław–Szczytniki type axes from the Polish land (*Otto – Witter 1952*, 136, Tab. 14b: Z 481; *Sarnowska 1975*, 102–112, Tab. I–V; *Szpunar 1987*, 20–35; *Krause 2003*, CD–ROM; *Silska 2012*, 115–121, Tab. 9, adapted).
Obr. 15. Zastoupení cínu v sekerách typu Wrocław–Szczytniki z území Polska.

(phases 1–2) mark the I MH and II MH which correspond to the B A1a (= 4th phase of the ÚC). What is symptomatic, 89 % of these metal findings show Sn content lower than 1 wt%. A certain small group of the artefacts related to the I MH and II MH is characterized by Sn content oscillating around 10 wt%. This period corresponds to the Siedlce horizon, for which 78 % of the metal finds contain below 1 wt% of Sn (*Pare 2000*, 16–17, fig. 1.9).

In the II MH and III MH, corresponding to the B A1b (= 5th phase of the ÚC) the distribution of Sn in metal finds from the cemeteries of the Nitra group and Gemeinlebarn (phase 3) is bimodal. Nearly 30 % of these artefacts do not show features of an alloy, and in the case of others, the content of Sn reaches up to 10 wt%. This period matches the Głogów horizon for which 59 % of metal finds do not show Sn content above 1 wt% while in the remaining 34 % it does exceed the level of 2 wt% Sn. In the case of 6 % of the artefacts related to the Głogów horizon, Sn content reaches 10 wt%. The same is true for Denmark, where in the LN II all types of Sn classes are represented with 2–5 classes as dominant (Sn traces – 7.95 wt% Sn). In the central area of the ÚC (Saale – Unstrut in Thuringia, southern Saxony-Anhalt), the frequency of metal findings containing above and below 2 wt% of Sn is similar. In the peripheral zones (North Bohemia, Spree – Neisse, Riesa – Dresden – Bautzen, Berlin – Brandenburg and Mecklenburg – Western Pomerania), metals contain significantly less Sn and only in 21 % cases Sn content reaches more than 2 wt% (*Vandkilde 1996*, 161–162, fig. 145–147; *Pare 2000*, 16–19, fig. 1.9–1.12). Metal artefacts from the LN II in Denmark

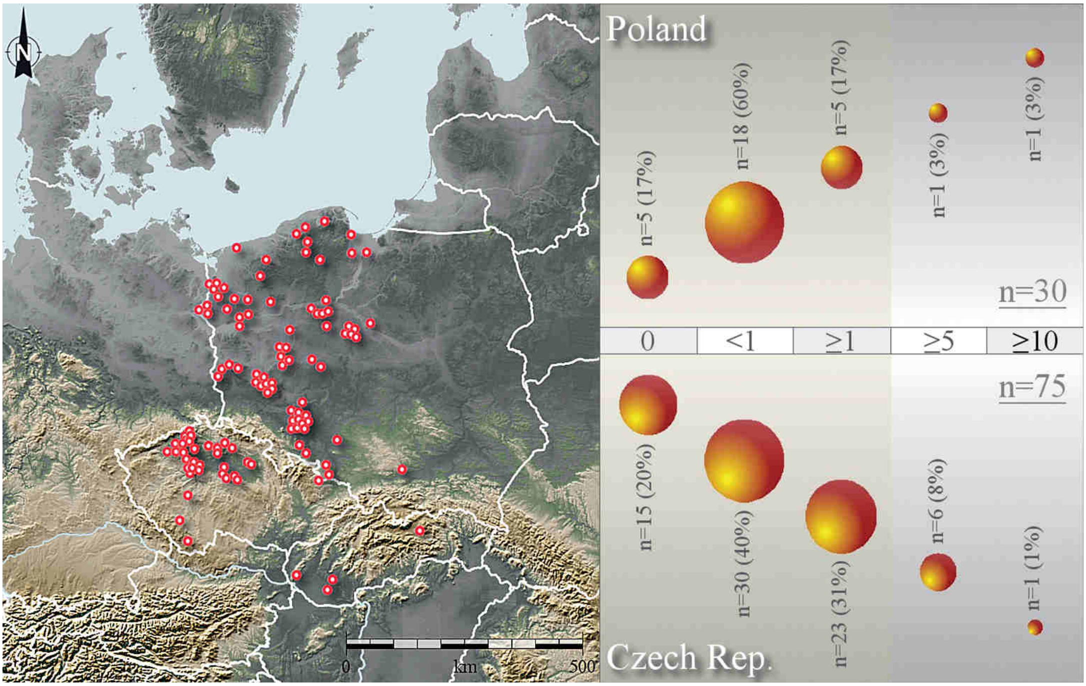

Fig. 16. Distribution of the Wrocław–Szczytniki type axes in Central-Eastern Europe with the alloy class frequencies (*Novotná 1970*, 33–37; *Szpunar 1987*, 20–35; *Blajer 1990*, 19–21, 97–150; *2001*, 314–321; *Moucha 2007*, 65–67, 99–166, Abb. 18; *Chvojka – Červenka 2008*; *Praumová – Šteffl 2013*; *Praumová et al. 2014*; *Šteffl – Krásný 2016*, adapted; map background: V. Junior/Shutterstock.com).
Obr. 16. Distribuce seker typu Wrocław–Szczytniki ve středovýchodní Evropě s vyjádřením četnosti typů slitin mědi.

show a distribution typical of the peripheral zone of the ÚC, although the frequency of bronzes with over 2 wt% of Sn is slightly higher there (over 34 %). It seems likely that the peripheral structure of bronzes is not distinctive exclusively for Pomerania, since an identical frequency of over 2 wt% Sn bronzes is evidenced by metal finds from other areas of the Polish land. Thus, the peripheral structure of bronzes can be spread over the entire ecumene of the ÚC and its satellite groups on the Polish land.

In the IV MH, corresponding to the B A2 (= 6th phase of the ÚC), the distribution of Sn in metal finds has been documented by a series of artefacts from Transdanube (Tolnanémedi series) in north-eastern Hungary and Transylvania (Hajdúsámson series). In these both series, there are hardly any copper artefacts. In the case of the remaining ones, the Sn content oscillates between 4 wt% and 10 wt% of Sn. This period matches the Pilszcz horizon, for which 86 % of artefacts show above 4 wt% content of Sn. The same applies to about the finds reported from Denmark where an important change in metallurgical praxis took place in the IA period. One of its consequences was a significant increase in the bronzes of 5 and 6 classes (*Vandkilde 1996*, 160, fig. 149–150; *Pare 2000*, 16–20, fig. 1.9–1.12).

In the period corresponding to the Siedlce–Głogów horizon, the Sn content in the majority of metal artefacts falls within the range from 0 wt% to 1 wt%. Such a distribution is

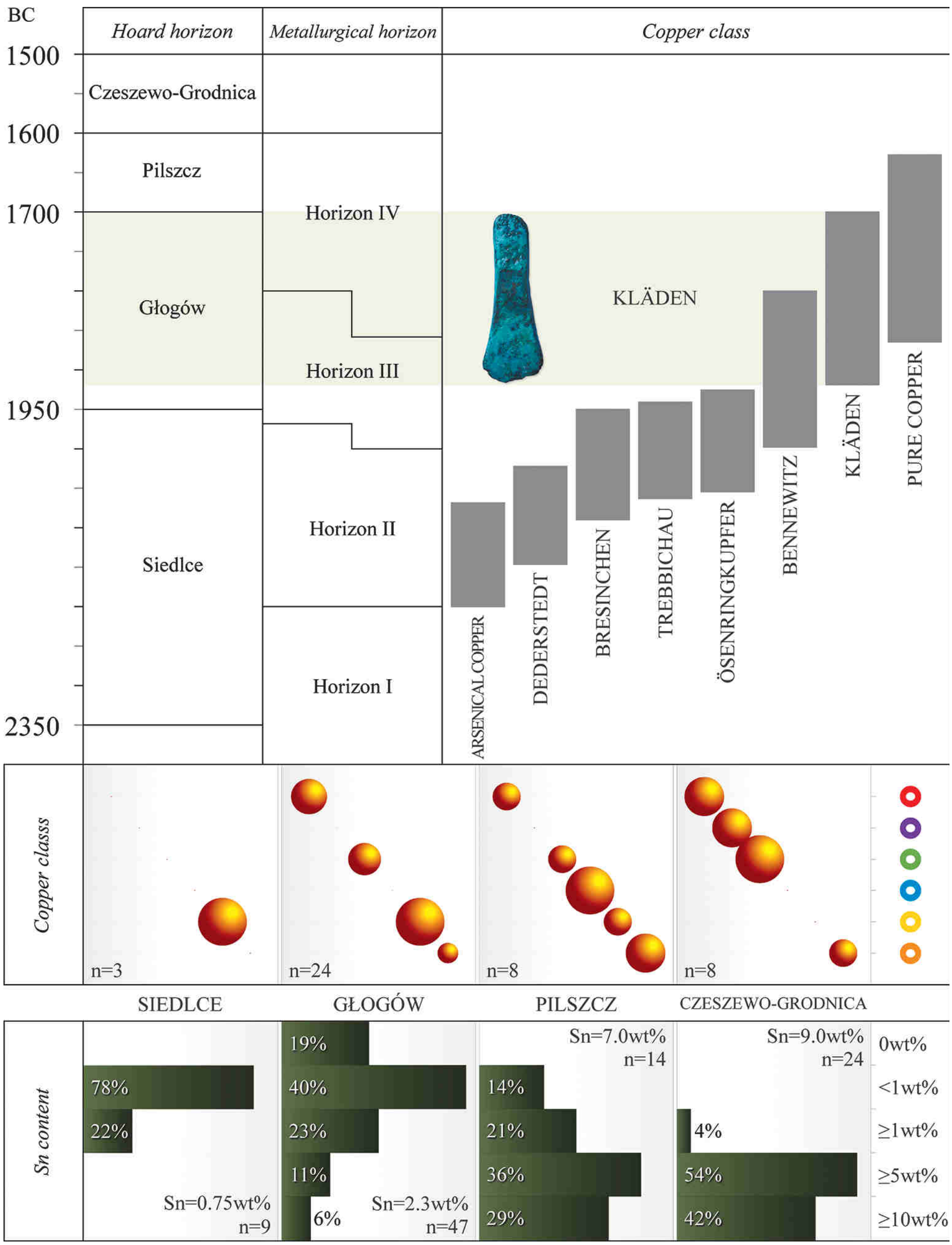

Fig. 17. Chronological diagram for the EBA and EBA/MBA on the Polish land with respect to the copper classes (*Otto – Witter 1952*, 136, Tab. 14b: Z 481; *Sarnowska 1975*, 102–112, Tab. I–V; *Blajer – Szpunar 1981*; *Szpunar 1987*, 20–35, Taf. 57; *Blajer 1990*, 19–21; *2001*, 259–268; *Vandkilde 1996*, 139–143, fig. 134; *Krause 2003*, 83–85, 90, Abb. 40, CD–ROM; *Rassmann 2010a*, 809, 812, Abb. 1, 4, Tab. 1; *2010b*, 712, Abb. 1; *Silska 2012*, 115–121, Tab. 9, adapted). ○ – 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).

Obr. 17. Chronologické schéma pro starší a přechod starší a střední doby bronzové na území Polska zohledňující jednotlivé třídy mědi. ○ – Ösenringkupfer I (A34: 1) ○ – arzénová měď (A34: 3) ○ – východoalpská měď (A34: 4) ○ – čistá měď (A34: 5) ○ – singenská měď (A34: 8) ○ – Ösenringkupfer II (A34: 10).

complemented by the other group where the Sn oscillates between 1 wt% and 10 wt%. This can suggest that peripheral metallurgists were not interested in casting standard bronzes, or, which is more likely, metal artefacts were imported as semi-products (*Spangenbarren*, *Ösenringbarren*, *Ösenhalsringe*). They could be re-melted on the spot or at some stage of the exchange route towards their final consumers[15] (*Harding 2000*, 218–219; *Vandkilde 2007*, 104; *Jaeger – Czebreszuk 2010*, 223).

Artefacts with low Sn content do not basically undergo chronological placing. However, it seems likely that the bronze alloys with the Sn content stabilized at the level from 8 wt% to 12 wt% (= B A2) are successfully raw-material dated. Presumably, metallic tin was already added to molten copper while in the older phases of the EBA (= Siedlce and partially Głogów horizons) tin minerals were rather obtained from alluvial deposits or roasted together with copper ores. Applying such (not fully controlled) metallurgical praxis probably caused the fluctuations recorded in Sn distribution, especially regarding the artefacts related to the Głogów horizon (*Pare 2000*, 19; *Vandkilde 2007*, 101; *Kienlin 2011*, 129; *2013*, 419).

The copper groups are successful in complementing the alloy sequences.[16] The distribution trends of the copper groups seem to be coherent for the central area of the ÚC and its peripheral zones (see *Vandkilde 1996*, 160–163, fig. 142–154). In the period matching the Siedlce horizon (= B A1a), only the presence of *Singen* copper has been registered (see *fig. 16*). However, when accepting that the II hoard from Żeńsko (gm. Krzęcin) was indeed deposited in the end of the B A1a phase (*Blajer 1990*, 83), the flow-in of *Ösenringkupfer* copper on the Polish land in the beginning of the Únětice horizon can also be a secured conclusion. Noticeably, such an assumption is in accordance with the distribution trends reported from the central area of the ÚC and its peripheries (*Kristiansen – Larsson 2005*, 123; *O'Brien 2015*, 162). Nevertheless, as far as the Polish land is regarded, this scenario did not become apparent until the Głogów horizon (= B A1b). In the period related to the III MH, so-called Eastern Alpine copper emerged in the ÚC ecumene (*Krause 2003*, 84, Abb. 34). It is noteworthy that a raised frequency of the Eastern Alpine copper occurrence among the metal finds connected with the Głogów horizon is slightly different from those observed in the remaining ÚC peripheries. It seems likely that the metal series from the Głogów horizon[17] can fingerprint the flow-in of a new raw-material, i.e. Eastern Alpine copper, not only in the form of ready-products (Únětice axes) but also semi-products (*Ösenhalsringe*). What is symptomatic, the emergence of the new copper type was coupled with an increase in Sn

[15] No casting metal-waste findings have so far been reported from the Polish land which could be related to the ÚC communities. It can be presumed that hoarding praxis existent during the EBA was concerning ready, selected metal artefacts and bronze metalworking was mainly done outside the Vistula and Oder Basins (*Blajer 2001*, 237).

[16] Generalizations about raw-material dating for artefacts recovered from the Polish land may cause some reservations. This directly results from a limited number of analyses, especially concerning the copper groups (70 analyses). Considering that over 800 metal finds are related to the EBA itself (from about 85 collective hoards), whereas the base of available results concerns the time-period between the B A1a and B B1, the validity of these conclusions may be questioned (*Blajer 2001*, 259). However, it seems that the raw–material sequences recorded for the Polish land are closely connected with the Central and North European trend, which allows to accept the validity of these conclusions. A key role could be played by raw-material analyses of longer metal series. Regrettably, during the World War II a considerable part of the original finds was lost (especially collective hoards), and therefore, complete observations and certain conclusions are impossible at this stage (see *Blajer 2001*, 31).

[17] Chronological placement of the eponymic collective hoard from Głogów can be placed towards the late B A2 or even the beginning of the B B1. This may be justified by three W–Sz D axes co-deposited there (*Szpunar 1987*, 34–35, Taf.: 10: 189–191; *Blajer 1990*, 19).

content in the alloy,[18] which for the bronzes cast from Eastern Alpine copper remains at the level of at least 4.8 wt% Sn[19] (*Krause 2003*, CD–ROM: SAM: 8940–8944).

In the central area of the ÚC, Eastern Alpine copper began to dominate over other groups during the IV MH (= Głogów/Pilszcz – Pilszcz horizon) and overlapped with the change of metallurgical praxis, which resulted in the stabilization of Sn content in bronzes at the level of 8–12 wt% (*Krause 2003*, 84, Abb. 34; *Kristiansen – Larsson 2005*, 123–125). The flow-in of Eastern Alpine copper is even more noticeable against the backdrop of the collective hoards with the ingot-like artefacts (*Ösenringbarren*, *Spangenbarren*, *Ösenhalsring*) reported from the Czech Republic (*fig. 18*). Nevertheless, during the IV MH in the Vistula and Oder Basins and also in other ÚC peripheries, the spread of this new copper type does somewhat show delay (the dominance of Eastern Alpine copper is not evident until the Czeszewo-Grodnica horizon). Eastern Alpine copper was still dominated by *Ösenringkupfer* copper, and in the case of the Polish land, also by pure copper. This, however, may result from an insufficient identification of the copper groups reported from the areas mentioned above (*Vandkilde 1996*, 160). Otherwise, this might be due to the so-called rationing of Eastern Alpine copper flow-in to the areas outside the central ÚC ecumene, where bronzes cast from previous types of copper (*Singen*, *Ösenringkupfer*) were still in circulation.

Except for the axe from Koperniki, only five more W–Sz axes have been reported from Central-Eastern Europe as cast from Eastern Alpine copper[20] (*fig. 19*; *tab. 2*). However, owing to the differentiated Sn content in these axes, they do not seem to bear uniform chronological placement. Consequently, the axes from Moczyły (gm. Kołbaskowo; Sn = 0.14 wt%; deposited as a single aquatic hoard), Bečov (okr. Most; Sn = 0.58 wt%) and Úľany nad Žitavou (okr. Nové Zámky; Sn = 0 wt%) should be matched with the Głogów horizon, whereas the axe from Rusy (gm. Braniewo; Sn = 5.5 wt%) and the last one of such, deposited in the hoard from Głogów (gm. *loco*; Sn = 4.3 wt%), can be ranged from the transition period of to the Głogów/Pilszcz up to the end of the Pilszcz horizon.

From the above, it seems reliable to hallmark the coupling of Eastern Alpine copper and an increased Sn content (Sn > 5 wt%) with a chronological sensitivity. This phenomenon is already registered in the Vistula and Oder Basins in the transition period of the Głogów/ Pilszcz horizon and it became far more common in the Pilszcz horizon (*Sarnowska 1969*, 340–343, ryc. 155: s–ż; *Novotná 1970*, 33, Taf. 9: 163; *Szpunar 1987*, 22, 30, Taf. 6: 112, 9: 158; *Krause 2003*, CD–ROM: FMZM: 1640, SAM: 8940, 10665, 19990; *Moucha 2007*, 100, Taf. 87: 4, Tab. 3). Hence, the chronological placement of the axe from Koperniki must be limited by the late phase of the Głogów horizon (1750/1700 BC) and the final stage of the Pilszcz horizon (1600 BC), which in fact closed up the series of the Únětice hoards in the Vistula and Oder Basins.

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[18] In 1975 *W. Sarnowska* (*1975*, 100), on the basis of the *Ösenhalsringe* necklaces distribution, came to the correct conclusions concerning the presence of Alpine copper in the Vistula and Oder Basins. Indeed, as the results of comparative studies of North Alpine area show, nearly 80 % of the *Ösenhalsringe* necklaces were cast from type III of Eastern Alpine copper (*Krause 2003*, 92–97, Abb. 47).

[19] What causes serious objections is the quality of some quantitative results for the collective hoard from Głogów (*Sarnowska 1975*, 108–112, Tab. III: 3–5, Tab. IV: 3–5, Tab. V: 3). Therefore, their assessment and reference to earlier results obtained for the Głogów metal series is practically impossible.

[20] The copper profile of the axe from Moczyły strictly refers to Eastern Alpine copper (*Szpunar 1987*, 30, Taf. 9: 158; *Krause 2003*, CD–ROM: FMZM: 1640; see also footnote no. 13).

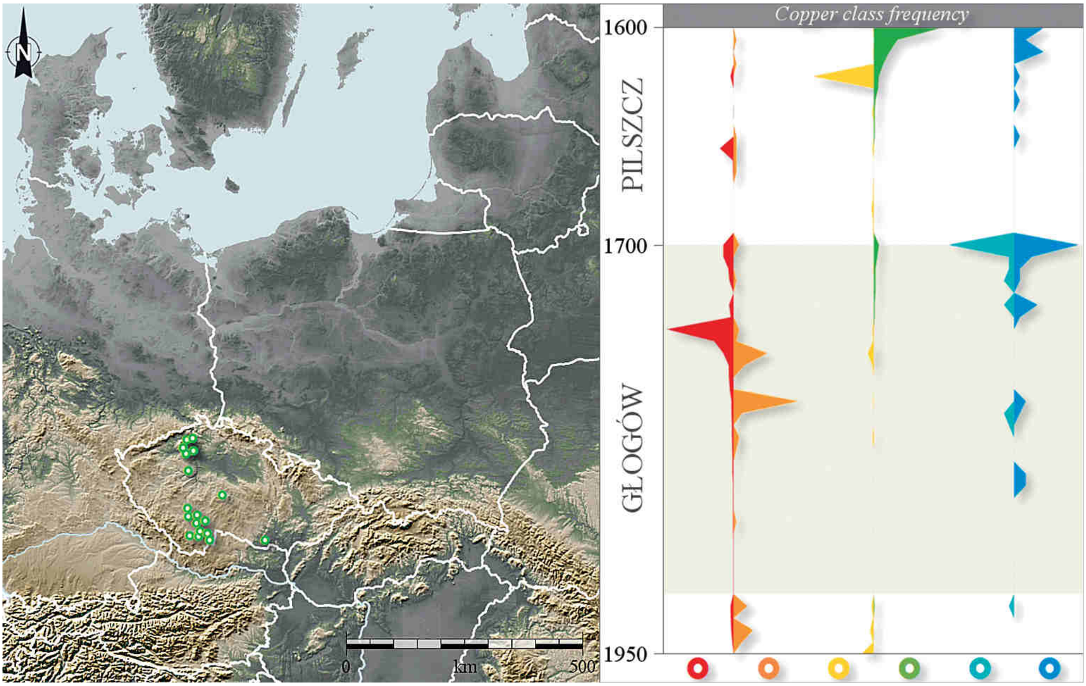

Fig. 18. The copper class frequencies in the EBA hoards of the ingot-like artefacts (*Ösenringbarren, Spangenbarren, Ösenhalsring*) from the Czech Republic with a distribution of Eastern Alpine copper (*Krause 2003*, 90, Abb. 40, CD–ROM; *Moucha 2007*, 93–96, 99–166, 167–292, Tab. 1–253; adapted; map background: V. Junior/Shutterstock.com). ⭘ – Ösenringkupfer I (A34: 1) ⭘ – Ösenringkupfer II (A34: 10) ⭘ – Singen copper (A34: 8). ⭘ – Eastern Alpine copper (A34: 4) ⭘ – purest copper (A34: 2) ⭘ – pure copper (A34: 5).

Obr. 18. Četnosti tříd mědi v depotech ingotovitých předmětů starší doby bronzové (*Ösenringbarren, Spangenbarren, Ösenhalsring*) z České republiky s distribucí východoalpské mědi (*Krause 2003*, 90, Abb. 40, CD–ROM; *Moucha 2007*, 93–96, 99–166, 167–292, Tab. 1–253; upraveno; mapový podklad: V. Junior/Shutterstock.com). ⭘ – Ösenringkupfer I (A34: 1) ⭘ – Ösenringkupfer II (A34: 10) ⭘ – singenská měď (A34: 8) ⭘ – východoalpská měď (A34: 4) ⭘ – ryzí měď (A34: 2) ⭘ – čistá měď (A34: 5).

B A1b (= Głogów horizon): Jizerní Vtelno I, okr. Mladá Boleslav; Jizerní Vtelno II, okr. Mladá Boleslav; Praha 6 – Bubeneč I; Praha 6 – Bubeneč II; Stará Boleslav, okr. Praha – východ; **B A1b/B A2** (= Głogów/Pilszcz horizon): Albrechtice nad Vltavou, okr. Písek; Blažim, okr. Louny; Český Brod, okr. Kolín; Český Heršlák, okr. Český Krumlov; Dušníky nad Vltavou, okr. Mělník; Heřmaň, okr. Písek; Hospozín, okr. Kladno; Jaroslavice, okr. České Budějovice; Kosov, okr. České Budějovice; Krtely, okr. Prachatice; Lukavec, okr. Litoměřice; Milevsko – IVO, okr. Mělník; Mladé, okr. České Budějovice; Švermov-Motyčín, okr. Kladno; Neznašov, okr. České Budějovice; Písek II, okr. *loco*; Písek, okr. *loco*; Praha – IVO; Radostice, okr. Litoměřice; Roudnice nad Labem, okr. Litoměřice; Smiřice, okr. Hradec Králové; Soběchleby, okr. Louny; Soběnice, okr. Litoměřice; Stehelčeves, okr. Kladno; Suché Vrbné, okr. České Budějovice; Vepřek, okr. Mělník; Vitín, okr. České Budějovice; Vrapice, okr. Kladno; Všemyslice, okr. České Budějovice; **B A2** (= Pilszcz horizon): Bavoryně, okr. Beroun; Březí near Trhové Sviny, okr. České Budějovice; Dolní Chrášťany, okr. Prachatice; Havalda, okr. Český Krumlov; Hluboká nad Vltavou, okr. České Budějovice; Hradiště, okr. Písek; Kublov, okr. Beroun; Litoměřice – IVO, okr. *loco*; Luštěnice, okr. Mladá Boleslav; Písek I, okr. *loco*; Plav, okr. České Budějovice; Praha 7 – Holešovice; Slavče, okr. České Budějovice; Staré Místo, okr. Jičin; Stradonice, okr. Kladno; Stradonice, okr. Louny; Temelín, okr. České Budějovice; Třebovle, okr. Kolín.

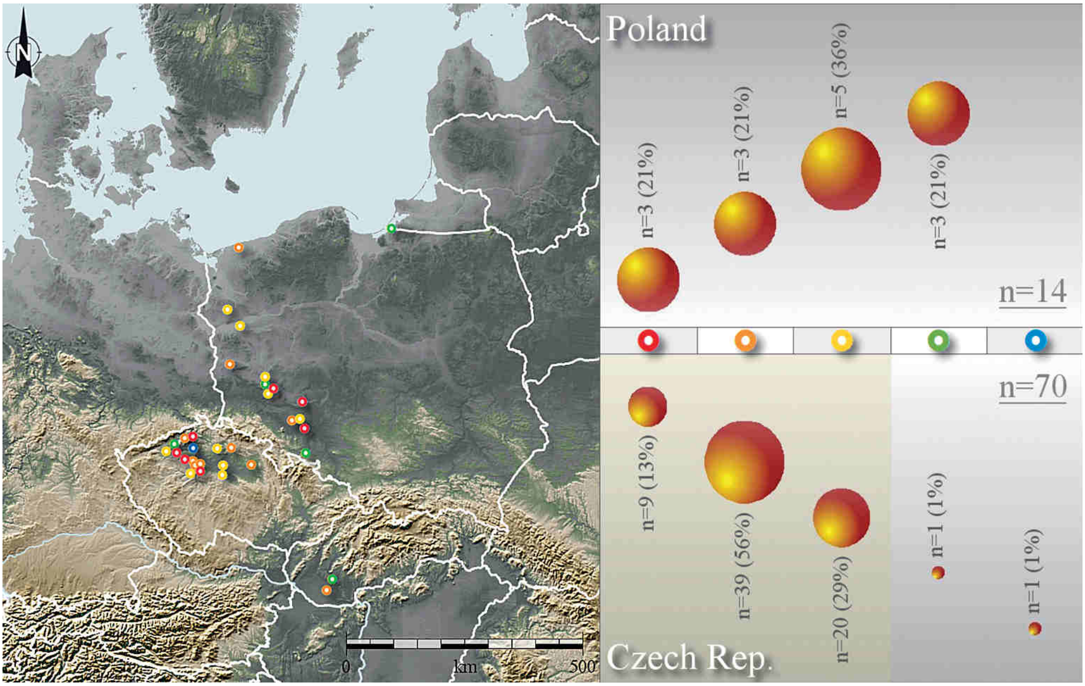

Fig. 19. Distribution of the Wrocław–Szczytniki axes in Central–Eastern Europe with the copper class frequencies (*Novotná 1970*, 33–37; *Szpunar 1987*, 20–35; *Blajer 1990*, 19–21, 97–150; *2001*, 314–321; *Krause 2003*, 83–85, 90, Abb. 40, CD–ROM; *Moucha 2007*, 65–67, 99–166, 167–292, Abb. 18, Tab. 3–262, adapted; map background: V. Junior/Shutterstock.com). ⭘ – Ösenringkupfer I (A34: 1) ⭘ – Ösenringkupfer II (A34: 10) ⭘ – Singen copper (A34: 8) ⭘ – Eastern Alpine copper (A34: 4) ⭘ – Pure copper (A34: 5).
Obr. 19. Distribuce seker typu Wrocław–Szczytniki ve středovýchodní Evropě s vyjádřením četnosti jednotlivých tříd mědi. ⭘ – Ösenringkupfer I (A34: 1) ⭘ – Ösenringkupfer II (A34: 10) ⭘ – singenská měď (A34: 8) ⭘ – východoalpská meď (A34: 4) ⭘ – čistá měď (A34: 5).

It should be emphasized that the results of analysis concerning the raw-material profiles are likely to force essential presumptions regarding the chronological placement of the W–Sz axes. It may be found as a striking regularity that all the W–Sz axes reported from Central–Eastern Europe as cast from *Singen* copper (*tab. 2*) were not in fact enriched with Sn (Sn < 1 wt%), except only one case (see *tab. 2: 80*). Taking a closer look at the general population of W–Sz axes found in Poland and the Czech Republic may lead to a conclusion that the frequencies of these specimens occurrence are comparable and reach 36 % (n=5) and 29 % (n=20), respectively (*fig. 19*). Interestingly, in terms of the metalworking praxis, this can be considered as a deliberate abandonment of the genuine bronze alloying. It might result from the technological properties of *Singen* copper (*Fahlerzmetalle*) bearing some (technological) resemblance to bronze alloy. What is more important, this could, in fact, mean that the EBA metalworkers were fully aware of *Singen* copper advantages and used it as an equivalent of Sn–bronzes, as it may be justified by e.g. the Salez axes (*Kienlin 2011*, 128–135). Here, it appears that the absence of Sn in the alloy was initially caused by the lack of this raw-material, whereas later, by its deliberate abandonment.

no.	Land	Type	Sn				
			0	<1	≥1	≥5	≥1
1	PL	*W–Sz A*	■				
2	PL	*W–Sz*	■				
3	CZ	*W–Sz A*	■				
4	CZ	*W–Sz B*	■				
5	CZ	*W–Sz C*	■				
6	CZ	*W–Sz C*	■				
7	PL	*W–Sz A*		■			
8	CZ	*W–Sz*		■			
9	CZ	*W–Sz*		■			
10	CZ	*W–Sz*			■		
11	CZ	*W–Sz*			■		
12	CZ	*W–Sz*			■		
13	CZ	*W–Sz*	■				
14	CZ	*W–Sz*	■				
15	CZ	*W–Sz*	■				
16	CZ	*W–Sz*	■				
17	CZ	*W–Sz C*	■				
18	CZ	*W–Sz C*	■				
19	CZ	*W–Sz C*	■				
20	PL	*W–Sz A*		■			
21	PL	*W–Sz A*		■			
22	CZ	*W–Sz*		■			
23	CZ	*W–Sz*		■			
24	CZ	*W–Sz*		■			
25	CZ	*W–Sz*		■			
26	CZ	*W–Sz A*		■			
27	CZ	*W–Sz B*		■			
28	CZ	*W–Sz B*		■			
29	CZ	*W–Sz C*		■			
30	PL	*W–Sz*			■		
31	CZ	*W–Sz*			■		
32	CZ	*W–Sz*			■		
33	CZ	*W–Sz*			■		
34	CZ	*W–Sz*			■		
35	CZ	*W–Sz*			■		
36	CZ	*W–Sz*			■		
37	CZ	*W–Sz*			■		
38	CZ	*W–Sz*			■		
39	CZ	*W–Sz*			■		
40	CZ	*W–Sz*			■		
41	CZ	*W–Sz*			■		
42	CZ	*W–Sz*			■		
43	CZ	*W–Sz*			■		
44	CZ	*W–Sz*			■		
45	CZ	*W–Sz*			■		
46	CZ	*W–Sz*			■		
47	CZ	*W–Sz*			■		
48	CZ	*W–Sz*			■		
49	CZ	*W–Sz*				■	
50	CZ	*W–Sz*				■	
51	CZ	*W–Sz A*				■	
52	CZ	*W–Sz A*				■	
53	CZ	*W–Sz A*				■	
54	CZ	*W–Sz A*				■	
55	SL	*W–Sz A*				■	
56	PL	*W–Sz C*	■				
57	CZ	*W–Sz A*	■				
58	CZ	*W–Sz B*	■				
59	PL	*W–Sz C*		■			
60	PL	*W–Sz A*		■			
61	PL	*W–Sz A*		■			
62	PL	*W–Sz A*		■			
63	CZ	*W–Sz*		■			
64	CZ	*W–Sz*		■			
65	CZ	*W–Sz*		■			
66	CZ	*W–Sz*		■			
67	CZ	*W–Sz*		■			
68	CZ	*W–Sz*		■			
69	CZ	*W–Sz*		■			
70	CZ	*W–Sz*		■			
71	CZ	*W–Sz*		■			
72	CZ	*W–Sz*		■			
73	CZ	*W–Sz*		■			
74	CZ	*W–Sz A*		■			
75	CZ	*W–Sz A*		■			
76	CZ	*W–Sz A*		■			
77	CZ	*W–Sz C*		■			
78	CZ	*W–Sz C*		■			
79	CZ	*W–Sz C*		■			
80	CZ	*W–Sz A*			■		
81	SL	*W–Sz C*	■				
82	CZ	*W–Sz A*		■			
83	PL	*W–Sz*			■		
84	PL	*W–Sz*				■	
85	PL	*W–Sz A*					■
86	CZ	*W–Sz*					■

Ösenringkupfer I (A34: 1); *Ösenringkupfer II (A34: 10)*; *Singen copper (A34: 8)*; *Eastern Alpine copper (A34: 4)*; *Pure copper (A34: 5)*

Tab. 2. The copper and alloy profiles of the Wrocław–Szczytniki type axes from Central-Eastern Europe.
Tab. 2. Prvkové složení mědi a měděných slitin seker typu Wrocław–Szczytniki ze středovýchodní Evropy.
1 – Rzeczyca, gm. Grębocice; 2 – Wyszkowice, gm. Domianów; 3–6, 14, 17–19, 22, 27, 53, 64–65, 75–79 – Soběchleby, okr. Louny; 7 – Sucha Wielka, gm. Trzebnica; 8 – Praha 6 – Podbaba; 9–11, 23–24, 31–45, 49 – Soběnice, okr. Litoměřice; 12, 51–52, 72 – Slaný, okr. Kladno; 13, 63 – Kosořice, okr. České Budějovice; 15, 66, 73 – Žatec, okr. Louny; 16, 25 – Čistěves, okr. Hradec Králové; 20 – Wierzbice, gm. Kobierzy; 21 – Nowy Zagór, gm. Dąbie; 26, 29, 57, 70–71, 74 – Praha 6 – Liboc; 28, 58 – Třískolupy, okr. Louny; 30 – Śliwin, gm. Rewal; 46 – Staré Místo, okr. Jičín; 47 – Minice, okr. Mělník; 48 – Předměřice nad Labem, okr. Hradec Králové; 50 – Praha 8 – Libeň; 54 – Praha 6 – Vokovice; 55 – Nesvady, okr. Komárno; 56 – Deszczno, gm. *loco*; 59 – Siedlce, gm. Lubin; 60 – Lipiany, gm. *loco*; 61 – Kotla, gm. *loco*; 62 – Wrocław–Pilczyce; 67 – Holašovice, okr. České Budějovice; 68 – Kluk, okr. Nymburk; 69 – Libodřice, Kolín; 80 – Hořelice, okr. Praha-západ; 81 – Úľany nad Žitavou, okr. Nové Zámky; 82 – Bečov, okr. Most; 83 – Głogów, gm. *loco*; 84 – Rusy, gm. Braniewo; 85 – Koperniki, gm. Nysa; 86 – Roudnice nad Labem, okr. Litoměřice (*Novotná 1970*, 33–37; *Sarnowska 1975*, 102–112, Taf. I–V; *Szpunar 1987*, 20–35; *Blajer 1990*, 19–21, 97–150; *2001*, 314–321; *Krause 2003*, 90, Abb. 40, CD–ROM; *Moucha 2007*, 99–166, 167–292, Taf. 3–262).

Assuming that hoarding praxis existent at the turn of the Głogów and Pilszcz horizon did not involve a long-term circulating W–Sz axes, those ones cast from *Singen* copper[21] should be ranged between the B A1a and B A2.[22] This statement could be meaningful if we established whether these axes were manufactured in one metallurgical center, because sharing the employment of the same technological praxis by other centers (in the context of the already facilitated access to Sn raw-material) seems doubtful. The coherence of this hypothesis is however disturbed by the fact that those Bennewitz, Lausanne I or Lanquaid I and II axes (which are partially synchronous with the W–Sz axes), reported as composed of *Singen* copper, were finally cast from genuine bronzes (*Novotná 1970*, 38, Taf. 11: 211; *Mayer 1977*, 91–96, Taf. 19, 134; *Szpunar 1987*, 36–43, Taf. 17; *Krause 2003*, 90, Abb. 40, CD–ROM; *Moucha 2007*, 65–67, 109–158, Taf. 70–85; Tab. 45–220). Consequently, a short chronology of the W–Sz axes discussed is far more likely, and thus, may lead to a conclusion that the Únětice axes horizon in Central–Eastern Europe was opened by *Singen* copper. This concept shows a certain chronological sensitivity which may be ranged from B A1a/b to B A1b (= Siedlce/Głogów – Głogów horizon). Such a scenario does not deny the presence of such axes in the hoards dated to the transition period of the Głogów/Pilszcz horizon, but only with the assumption that the deposition act concerned a variety of metal objects, also including those circulating for a long period of time. It cannot be rejected that the concept the short chronology is also true for the W–Sz axes composed of *Ösenringkupfer* copper, but only for those reported as not cast from genuine bronze (Sn < 1 wt%).

6. Final remarks

The axe from Koperniki is the smallest representative of the primitive low-flanged Únětice axes recovered from the Polish land. The axe was cast from so-called Eastern Alpine copper, in a metallurgical workshop of the ÚC, most probably outside the area of the Vistula and Oder Basins. Although the casting was intensively plastic-worked out, the axe from Koperniki itself was not used in the past. Hence, the statement that the axe was intended to serve as a prestigious or insignia metal object rather than fulfill utilitarian functions seems reasonable. In the period between the B A1b and B A2 (1750/1700–1600 BC), the Lower Silesian ÚC communities from Paczków Foothills became the owners of the axe "from Koperniki" which was finally deposited in the stream bed as a so-called aquatic single hoard or abandoned.

The findings of the W–Sz axes from the Polish land constitute the richest collection of such in Central–Eastern Europe. It should be taken for granted that the specimens cast from *Singen* and perhaps also *Ösenringkupfer* copper opened up the Únětice axes horizon on the Polish land (= Siedlce horizon), whereas the last W–Sz axes emerging in the Odra and Vistula Basins (= Pilszcz horizon) were composed of Eastern Alpine copper.

[21] The hoards from Praha 6 – Liboc, Slaný, Soběchleby, or Žatec can be mentioned here (*Krause 2003*, 90, Abb. 40, CD–ROM; *Moucha 2007*, 143–166, Taf. 57–191, Tab. 173–262).

[22] *Singen* copper was also available during the Pilszcz horizon (= B A2), as may be justified by e.g. the hoard of 78 so-called copper rib–ingots (*Spangebarren*) from Havalda (*Krause 2003*, 90, Abb. 40, CD–ROM; *Moucha 2007*, 106–107, Taf. 1–14, Tab. 36; *fig. 18*).

In some cases, the raw-material profile may contribute to the chronological gradation of the Únětice hoards.[23] A uniform raw-material structure of the metal objects deposited in the collective hoards should be the key to such a gradation. This applies especially to the Głogów horizon and may be justified by e.g. a hoard from Lipiany[24], gm. *loco* (*Blajer 1990*, 118, tab. LV: 1–4; *2001*, 315). However, concerning the hoards of the Únětice axes or single finds of those in general, the lack of traces indicative of the use or re-sharpening should awaken some caution, since the axes themselves could possibly be used as insignia, function as commodity money (*Gerätegeld*) or be intended to serve as the copper ingots. Although all these possibilities are not mutually exclusive, they apparently could extend the social life[25] of metal object. Consequently, the reliability of raw-material dating, and thus, chronological gradation of the hoards, including especially those ones reported as single depositions, can be questioned.

According to the raw-material dating results, it was already at the turn of the Siedlce and Głogów horizon (= B A1a/b) when the Únětice axes and other metal objects emerged in the area of Pomerania (Iwno culture, Płonia group). Contrary to the self-isolating communities of Little Poland which were still following the post-Neolithic cultural patterns, the EBA elites from northern Poland were able to generate adequate demand for metal objects and made themselves capable of satisfying such a mimetic desire (*Kadrow 2001*, 230). This demand was probably answered by the secondary–centers in which such goods were redistributed and perhaps socially reinterpreted. The Lower Silesian centers or the defensive settlement of the Kościan group in Bruszczewo can be mentioned here (*Jaeger – Czebreszuk 2010*). The process of integrating the ÚC ecumene and its satellite groups from the Polish land with the EBA civilization may be reflected by the stable flow–in of bronzes to the Vistula and Oder Basins and the statement that this process was strong enough to petrify into a *longue durée* structure seems reliable. Therefore, at least some of the cultural patterns brought by this process to the peripheral elites from northern Poland[26] were still existent during the disintegration of the Únětice–world system, or even after it finally collapsed.

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[23] The chronological gradation discussed refers to the manufacturing rather than hoarding act of the metal objects.

[24] The hoard from Lipiany should in fact be placed in the older phase of the Głogów horizon. This may be justified by coherent raw–material structure of metal objects deposited there. These are, the W–Sz axe A and 3 band ornaments, all reported as cast from Singen copper (*Blajer 1990*, 118, tab. LV: 1–4; *2001*, 315; *Krause 2003*, CD–ROM: SAM: 9680–9682).This observations are interesting in the context of emerging the metal objects in the area of the Polish land, and thus, may suggest that the EBA elites of Lower Oder Basin (Płonia group) could have been one of the very first consumers of such goods.

[25] The social life of the artefact refers to all the stages it was present in the past, beginning from manufacturing, through stage of circulating to a final act of deposition. In terms of metal objects (but also e.g. pottery) there can be also distinguished a stage of *the death-and-reborn* of the artefact, which might have involved a process of recycling and re-using so obtained raw-material, however in the case of the Únětice axes this is hardly justified.

[26] These were, not only social patterns (e.g. social polarization) but also those one of rather utilitarian nature, such as, for instance, creating local metalworkshops, or even original metallurgical style, as may be justified by e.g. metal findings from Pruszcz Gdański or the Łuszczewo type axes, all attributed to the Iwno culture communities (*Szpunar 1987*, 47–49, Taf. 14: 264–273, Taf. 15: 274; *Bokiniec 1995*).

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