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Urban Copper-based Technology in Brno
Archaeometallurgical Analysis of Finds from Brno–Pekařská Street

Abstract

The study presents the main results of 417 archaeometallurgical analyses of a diverse assemblage (1504 individual artefacts) of especially non-ferrous (mainly copper-based) artefacts acquired from the rescue excavation in Brno–Pekařská Street (okr. Brno-město/CZ) in 1989. The finds are chronologically dated to the late 15th century and the first half of the 16th century and consist mainly of dress accessories, but also jewellery, personal hygiene items, other household utensils and objects related to spiritual culture. The investigation comprises of several analytical methods including pXRF, optical microscopy and metallography with SEM/EDS. The general material composition shows the dominant use of brass with the main peak at 17 % of Zinc and reaching up to 36 %, followed by gunmetal (tin brass or so-called red brass), occasional occurrence of unalloyed copper, and singular presence of tin bronze. The results showed different strategies of material usage for specific groups, e. g. high brass for pins, gunmetal for buckles and unalloyed copper for scrap sheets.

Keywords

Brno / Late Middle Ages / Early Modern period / non-ferrous metals / brass / copper / elemental composition / pXRF / metallography

Excavations in the centres of medieval cities frequently yield numerous and diverse collections of small, particularly metal finds documenting an important aspect of the material culture of that period – especially different types of dress accessories. To a lesser extent, these artefacts are also found at other types of settlements (e. g. Lithberg 1932; Brennan 2001; Krabath 2001; Egan/Pritchard 2002; Ottaway/Rogers 2002; Lungershausen 2004; Schlenker 2007; Trawicka 2010; Berger 2012; Miścicki 2017; Carrera 2018; Sawicki 2017; 2021; Cassitti 2021). The collection of archaeological finds from Brno–Pekařská Street (okr. Brno-město/CZ) is no exception, but it is characterised by some specifics (preliminarily Procházka 1990). The boom in the production of small artefacts (particularly dress accessories) made of non-ferrous metals (especially brass and tin/lead alloys) during the Late Middle Ages was accompanied by standardisation and the emergence of supra-regional forms and shapes (Cassitti 2018, 97–98).

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The Excavation and Finds

In January 1989, a rescue excavation was conducted on both sides of the buried millstream in the immediate vicinity of the defunct bridge in Pekařská Street. The excavation was prompted by the construction of the M1 pavilion of the St. Anne's University Hospital Brno (**fig. 1**). The site is part of the historical district of Staré Brno (Old Brno). In the 11th and 12th centuries, it was a pre-location agglomeration, and in the 13th century, it evolved into a small town that became part of the suburbs of the medieval and Early Modern city of Brno. The mentioned millstream probably already existed in the 13th century in the form of a relatively wide, shallow stream. During the Late Middle Ages, it was irregularly delimited by piling until the 18th century, when it was significantly narrowed by brick walls.

During the excavation, a layer (4a) of pebbles, ash, sandy clay, household and other waste with a thickness of 20–30 cm was found at a depth of 3 m below the recent surface on the northwest side of the construction pit, already at the ground water level. The excavated soil was sieved in place, making it possible to capture even very small finds, including dozens of coins. That layer differed from other similar settlement deposits by an extraordinary concentration of metal artefacts, predominantly non-ferrous finds, mostly copper alloys (more than 90 % of the assemblage), but also iron, tin/lead alloys and non-metallic materials. The set of finds is chronologically dated to the Late Middle Ages and Early Modern period, more specifically to the late 15th and the first half of the 16th century.

The mentioned assemblage of mostly non-ferrous finds, which is the subject of the presented article, was concentrated close to the bridge, on its northwest side. A robust waste layer with a high proportion of ceramic fragments was found on the opposite southeast side of the excavation area downstream of the mill race. This waste deposit was situated roughly in the same stratigraphic position as layer 4a, but metal finds were rather rare. Above these layers was a sequence of modern deposits (18th and 19th c.), which also contained metal finds, but in significantly smaller quantities.

The dating of the assemblage is determined by the set of 71 coins with a considerable time span (as determined by PhDr. Jan Šmerda). The oldest coinage is represented by the *parvus* of John of Luxembourg (1310–1346) and two *parvi* of Charles IV (1346–1378). A coin of Leopold I (1657–1705) reached the lower part of layer 4a, and five coins from the reign of Francis II (1792–1835) are an intrusion from modern upper deposits. Most of the coins, however, are dated to the period from the end of the 14th to the first half of the 16th century.

The assemblage from the excavation in Brno – Pekařská Street consists of a total of 1504 individual artefacts from non-ferrous metals (copper alloys, tin/lead alloys). Most finds are related to dress accessories (pins, needles, hooks and eyes, buckles, mounts, lace chapes, belt segments, strap ends, buttons, bells), jewellery (rings, chains, pendants), cosmetics implements (ear scoop, tweezers) and other items from household equipment (knife handle, various small fittings, faucet, thimbles) and spiritual culture (seal matrix, book mounts). Another important part of the collection is scrap-metal finds/semi-products in the form of sheets and wires. In general, the largest group consists of pins in a number exceeding 700 pieces. The second largest group is composed of hooks and eyes in a number of more than 260 pieces.

The excavation in Pekařská Street and the acquired finds were preliminarily published quite soon after the end of the excavation (Procházka 1990). Some of the finds were published in the following years in thematic monographs (Šlancarová 2006; 2008; 2018; 2019) and an article (Macháňová et al. 2013), while certain preliminary results and observations of the presented archaeometallurgical analyses of finds from Pekařská Street were recently published in Czech (Kmošek/Procházka 2020).

Work is currently under way to create a comprehensive catalogue presenting all finds from the excavation including archaeological context, typological classification, dimensions and also detailed archaeometallurgical analyses. During the work, a significant amount of new data and observations related to the technology of the artefacts emerged, necessitating the writing of this article focused on the archaeometallurgical analysis of copper-based finds from Brno – Pekařská Street. The work presents the material and a technological analysis of copper-based finds focused on primary phenomena present in the collection, such as material composition, construction, and manufacturing technology. It employs several analytical methods including pXRF, optical microscopy, metallography with SEM/EDS. Even though archaeometallurgical analyses are occasionally performed on various collections from non-ferrous metals from the Late Middle Ages and the Modern period (Heyworth 2002; Lungershausen 2004, 150–155; Ottenwelter 2021; Caple 1992; Garbacz-Klempka et al. 2017), we still lack a general view

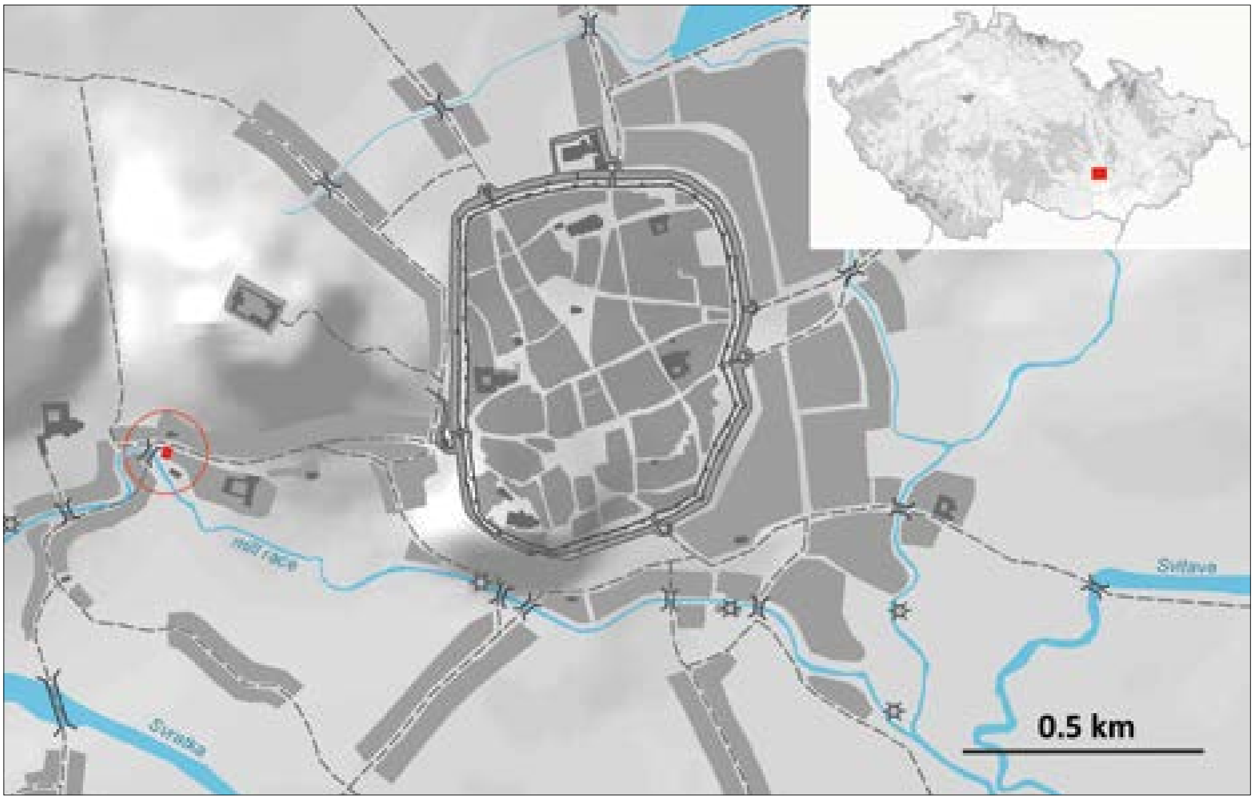

Fig. 1 Location of the archaeological site in Brno – Pekařská Street on ideal reconstructed plan of the city around 1500 – (Map after Kolařík/Procházka 2023, fig. 1).

of the relevant points. The presented article aims to partially fill the gaps in this concern focusing on the material from Brno – Pekařská Street.

From the perspective of archaeological and written sources, Brno was an important royal city during the Middle Ages with the presence of crafts working with non-ferrous metals. Metallurgical activities are evidenced from the 13th century, especially by finds of crucibles, a lead anvil, moulds, and rare *in-situ* production structures (Gregerová et al. 2011; Flodrová/Loskotová 1995; Hložek et al. 2004; 2006). The significant presence of zinc in some crucibles, starting with those from the turn of the 13th century, probably indicates the manufacture or processing of brass (Gregerová et al. 2011, 47–50; Procházka et al. 2011, 79–84). Written sources considering mainly taxation are preserved with gaps in the years 1343–1567 (esp. Mendl 1935; Urbánková/Wihodová 2008; Flodr 2005; 2010; Jordánková/Sulitková 2020)[1]. Their information value changes due to modifications in the principles of the taxation of Brno citizens, which mainly affects the data on the number and wealth of craftsmen (Dřímal 1964; Čechura 1998).

Crafts of non-ferrous metals have not yet been described in more detail based on written sources. They are briefly mentioned in several summary papers (Sulitková 1984, 66. 76. 81; Švábenský 1994, 180. 185). Goldsmiths, who were the best situated within the investigated groups of producers, were represented in the largest number. In smaller numbers, there were potters (literally kettle-producers) and pewterers, as well as bell-makers, coppersmiths and girdlers. It seems that in the 14th and 15th centuries it is not possible to clearly distinguish bell-makers and potters, which is also documented elsewhere (Smrž 2019, 181). In the 14th century, we often find bell-makers, and in the 15th century, many potters also made bells, some of which have been preserved in Brno and the surrounding area. Since 1387, potters had a joint guild with pewterers. The girdlers represented a non-negligible specialisation which occurs mainly at the end of the 14th century.

1 Most tax books and registers were not published and are stored in the Brno City Archive in the A1/3 collection. This paper draws on information from manuscripts nos 8, 9, 10, 22-29 from the years 1442-1477, 1477-1509, 1509-1538, 1471, 1487, 1499, 1504, 1510 and 1514. For more details on these sources, see Sulitková 1998.

In contrast to some other towns, Brno has no record of specialised brass workers (see e. g. Głowa/Garbacz-Klempka 2010, 101; Kröner 2018, 364–365; Sawicki 2018, 113). Needle-makers, button-makers, mirror-makers and buckle-makers appear only individually in sources from the 14th century. Nevertheless, for example, there is a surprising lack of reports about needle-makers who produced widely-used pins (Smrž 2019, 149–151). In the field of metalworking, Brno was probably only of regional importance because of the small number of specialisations and manufacturers represented (for Paris as an example of a large European city with many craftsmen working with copper, see e. g. Bourlet/Thomas 2018, 107). However, the basic structure of specialisations in this industry was similar in European medieval cities (Sawicki 2018, 113–114).

Some of the artefacts from non-ferrous metals found in Brno – Pekařská Street were undoubtedly produced by domestic craftsmen, as evidenced by the aforementioned finds of tolls and production structures. It is also supported by reports on the import of copper, e. g. for the year 1344 (Flodr 2005, 212 no. 526). In spite of this, especially in the Late Middle Ages and the Early Modern period, we have to count on imports from Nuremberg (DE), which had an exceptional position in the field of metal production and the distribution of its products. This applies in particular to segmented girdles and appliques (for Nuremberg metal production esp. Stahlschmidt 1970; Müller 2002; Cassitti 2016, 285; 2021; Kröner 2018).

Analytical Methodology of Copper-based Artefacts

Materials and Methods

The diverse collection of artefacts from Brno – Pekařská Street was visually examined and representative pieces were subjected to complex analytical methods concerning elemental composition analysis (pXRF), metallographic investigation and optical and electron microscopy. The research was focused on main topics concerning material composition, construction, and the manufacturing technology of the investigated collection. Through overall pXRF analyses, an evaluation of the material composition was performed for the collection as a whole and separately for each object type. Individual artefacts were selected to investigate the manufacturing technology of different types of artefacts by metallography and microscopy.

pXRF

The pXRF method was used to identify the overall elemental composition of the artefacts. Due to the high number of artefacts in the collection, large-scale non-destructive surface analyses using a pXRF spectrometer[2] were performed. This method allows the performance of fast and replicable analyses at the expense of lower precision and higher detection limits. Altogether, 480 pXRF analyses were performed. In this way, almost a third of the entire collection of finds from Brno – Pekařská Street was analysed. Analyses by pXRF were already performed on other medieval collections from different parts of Europe using similar methodology (e. g. Bottaini et al. 2022; Castelle et al. 2020).

No surface preparation has been carried out and thus the results of surface pXRF analysis are affected by surface contamination and corrosion. The surface of the artefacts is mostly well preserved with bright yellow colour of brass. However, some artefacts show traces of corrosion in the form of dezincification of the brass with reddish brown colour areas occurring in slow-moving or stagnant water (Scott 2002, 27), as in the case of the excavations in Pekařská Street.

A comparison of surface and bulk composition (for results see **tab. 1**) was conducted on selected artefacts (13 pieces) to determine the quality and validity of surface analysis results. Bulk analysis was performed on metal core samples acquired by drilling with 1 mm drill analysed by pXRF spectrometer under same conditions as surface analysis. As the majority of the artefacts in the collection were made of brass, the reliability of the copper and zinc content as the main elements presented was given the most attention. They showed only minor differences between the surface and bulk analysis results. For copper, the maximum relative error is 7.8 % and an average of 3.2 %. For zinc, the relative error is slight-

2 Portable X-ray fluorescence (pXRF) spectrometer Niton Xl3t 980 GOLDD+ with following measuring conditions: Ag Anode, acceleration voltage 50 kV, measuring time 10–30 s, General Metals mode, collimator 3 or 8 mm, automatic evaluation of spectra.

inv. no.	artefact	type of sample	Cu	Zn	Pb	Sn	Ni	Sb	Bi	Fe
A452143	right side attachment plate	surface	83.2	16.0	0.10	0.27	0.30	0.00	0.00	0.06
		bulk	84.4	15.3	0.11	0.00	0.22	0.00	0.00	0.05
	left side attachment plate	surface	83.1	16.2	0.09	0.29	0.30	0.00	0.00	0.06
		bulk	84.1	15.5	0.11	0.00	0.24	0.00	0.00	0.04
	horseshoe-shaped link	surface	87.5	11.5	0.57	0.00	0.14	0.05	0.00	0.19
		bulk	87.5	11.2	0.96	0.00	0.12	0.00	0.00	0.22
A452176	pin	surface	75.8	19.2	2.37	1.64	0.21	0.07	0.26	0.35
		bulk	74.2	18.5	5.68	0.66	0.17	0.00	0.35	0.44
A452180	wheel	surface	88.5	0.1	3.29	7.49	0.06	0.08	0.02	0.14
		bulk	87.6	0.0	7.83	4.31	0.03	0.00	0.04	0.19
A452192	buckle	surface	82.2	9.5	0.26	6.59	0.06	0.39	0.00	0.96
		bulk	84.5	9.1	2.66	2.68	0.04	0.05	0.00	0.93
A452202	knife fitting	surface	84.9	13.6	0.39	0.45	0.20	0.00	0.00	0.13
		bulk	83.8	14.5	1.29	0.00	0.17	0.00	0.00	0.17
A452271	buckle	surface	89.2	6.8	1.30	1.18	0.25	0.24	0.00	0.97
		bulk	82.2	7.1	7.89	1.02	0.20	0.18	0.00	1.34
A452324	*stilus*	surface	65.2	33.1	1.14	0.00	0.29	0.00	0.00	0.15
		bulk	63.5	30.4	5.60	0.00	0.22	0.00	0.00	0.19
A452550	button	surface	76.1	11.1	4.22	7.13	0.10	0.34	0.04	0.80
		bulk	73.4	10.6	10.93	3.55	0.07	0.00	0.00	1.24
A452672	knife handle	surface	75.3	18.7	0.86	3.09	0.34	0.37	0.00	0.95
		bulk	69.8	19.2	6.48	2.21	0.31	0.25	0.00	1.70
A452675	buckle	surface	87.0	8.4	0.43	2.03	0.51	0.13	0.00	1.28
		bulk	80.6	9.9	4.11	1.88	0.48	0.12	0.00	2.82
A452680	eye loop	surface	71.9	26.8	0.72	0.00	0.38	0.13	0.00	0.10
		bulk	71.5	26.6	1.45	0.00	0.35	0.00	0.00	0.12

Tab. 1 Comparison of surface and bulk pXRF analysis of selected artefacts (in wt %).

ly higher but still very reliable with a maximum of 17.9 % but an average of only 4.8 %. These average relative errors are similar to the integral error of the method used.

The comparison of lead and tin content detected by surface and bulk analysis is more problematic. The lead content on the surface is significantly undervalued compared to bulk analysis results. The difference is up to an order of magnitude, with a maximum relative error of 923 %, and an average of 159 %. For tin, on the other hand, we observe a completely opposite phenomenon with an overvaluation of the tin surface content with an average relative error of 55 %. Other admixture elements, such as nickel (Ni), antimony (Sb), bismuth (Bi), iron (Fe), have a low content (especially Sb, Bi) resulting in fluctuating error. However, for nickel, for example, the average relative error is only around 20 % (surface overvaluation) and for iron around 31 % (surface undervaluation).

For this reason, results of lead, tin and other admixtures were not largely taken into account during the evaluation of the collection. The results of surface analysis can therefore be considered qualitative and semi-quantitative at best. Nevertheless, the non-destructive pXRF results provide at least an indication of the alloys used in the manufacture of the analysed objects, and can be used for a general evaluation and comparison of the elemental composition, especially in the case of major elements and some admixtures.

Metallography

Metallographic samples taken by clipping were mounted in methyl methacrylate-based resin Technovit 4006. Preparation was conducted manually on a SMART LAM 2.0 metallographic grinding and polishing machine. Wet grinding was performed with 240, 600, 1200 and 3000 grit sandpaper, polishing with Bio Diamant NEODIA 3P and 1P abrasive suspension. Samples were cleaned after each step with isopropanol and dried with a stream of hot air. Microstructure observation and documentation was performed with a Nikon Eclipse LV100POL optical polarising microscope. Documentation by electron microscope and SEM/EDS elemental composition analysis involved a ZEUSS Evo LS–10 scanning electron microscope with an Oxford Instruments Xmax 80 mm^2 EDS detector[3].

Microscopy

Selected artefacts were examined and documented using optical microscopy to identify surface evidence of manufacture, use and damage. For this purpose, two digital microscopes were used. Coloured images were made with a Keyence VHX-5000[4] digital microscope and black and white images of artefact relief come from the LMI ToolScan[5] forensic examination system.

Results

The many results of the archaeometallurgical investigations are first evaluated in the general perspective of material composition, and then individual primary artefact types (mounts, pins, hooks and eyes, belt segments, scarp sheets and buckles) are analysed using the methods described. From the general perspective of material composition, the collection is made predominantly of copper alloys (93 %; n = 1484), but also iron (n = 65), tin/lead alloys (n = 21) and non-metallic materials (n = 29; glass, ceramic, wood, bone, leather, stone).

General Material Composition of Copper-based Artefacts

As mentioned above, the collection from Brno – Pekařská Street is mostly made from copper alloys (93 % of the finds). Therefore, most analysed artefacts are from this type of material (a total of 415 pXRF analyses). The general material composition of copper-based finds includes four main types of alloy used: brass, followed by gunmetal, occasional unalloyed copper and a single occurrence of tin bronze (**fig. 2a-b**). It is important to note that the general evaluation is influenced by the amount of different types of objects that are not even in the collection. Therefore, specific types of artefacts are also evaluated individually.

Distinguishing between different copper alloys is not completely sharp and the material shows a complex range of compositions. According to the distribution of zinc content, the boundary between brass/gunmetal and unalloyed copper was determined at 3 % of zinc. Deliberate alloying with tin (tin bronze/gunmetal) is arbitrarily set at 1 % of tin content. Lead content does not prove a significant potency in distinguishing different copper alloys (**fig. 2b**), but its influence was apparently significantly reduced by the alteration of its content on the surface (see p. 128–129). Even so, medieval artefacts show the accidental addition of lead to copper alloys, with little significance to the alloys that distinguish them (e. g. Bottaini et al. 2022). The material generally displays an admixture of tin, lead, nickel and antimony and trace amounts of silver, bismuth, and cobalt. The content of iron, chromium and titanium is also present but is most likely derived from surface contamination by soil impurities (**fig. 2d**).

Brass (copper alloyed with zinc) dominates the collection with around 80 % of the cases analysed. The minimal zinc content for brass is determined for

3 The elemental composition by SEM/EDS was acquired by the following conditions: acceleration voltage 10 kV and 15 kV; working distance 12 mm; dead time ca. 50 %; evaluation of spectra was performed using Oxford Aztec software. Precision of acquired elemental composition is around 0.5 %.

4 Keyence VHX-5000 digital microscope: 2D and 3D imagining of the surface, coloured camera, 1/1.8 type 1.95 million-pixel CMOS image sensor, 1600×1200 executable pixels, frame rate max. 50 f/s, automatic focusing of Z axis.

5 LMI ToolScan forensic examination system: 2D and 3D scanning of the surface, BW camera, 3 μm/px resolution, reconstruction of the surface by EDF and photometric stereo-lighting from eight different directions, motorised feed of XY table + focusing of Z axis, range of XYZ 100 mm. The elemental composition by SEM/EDS was acquired by the following conditions: acceleration voltage 10 kV and 15 kV; working distance 12 mm; dead time ca. 50 %; evaluation of spectra was performed using Oxford Aztec software. Precision of acquired elemental composition is around 0.5 %.

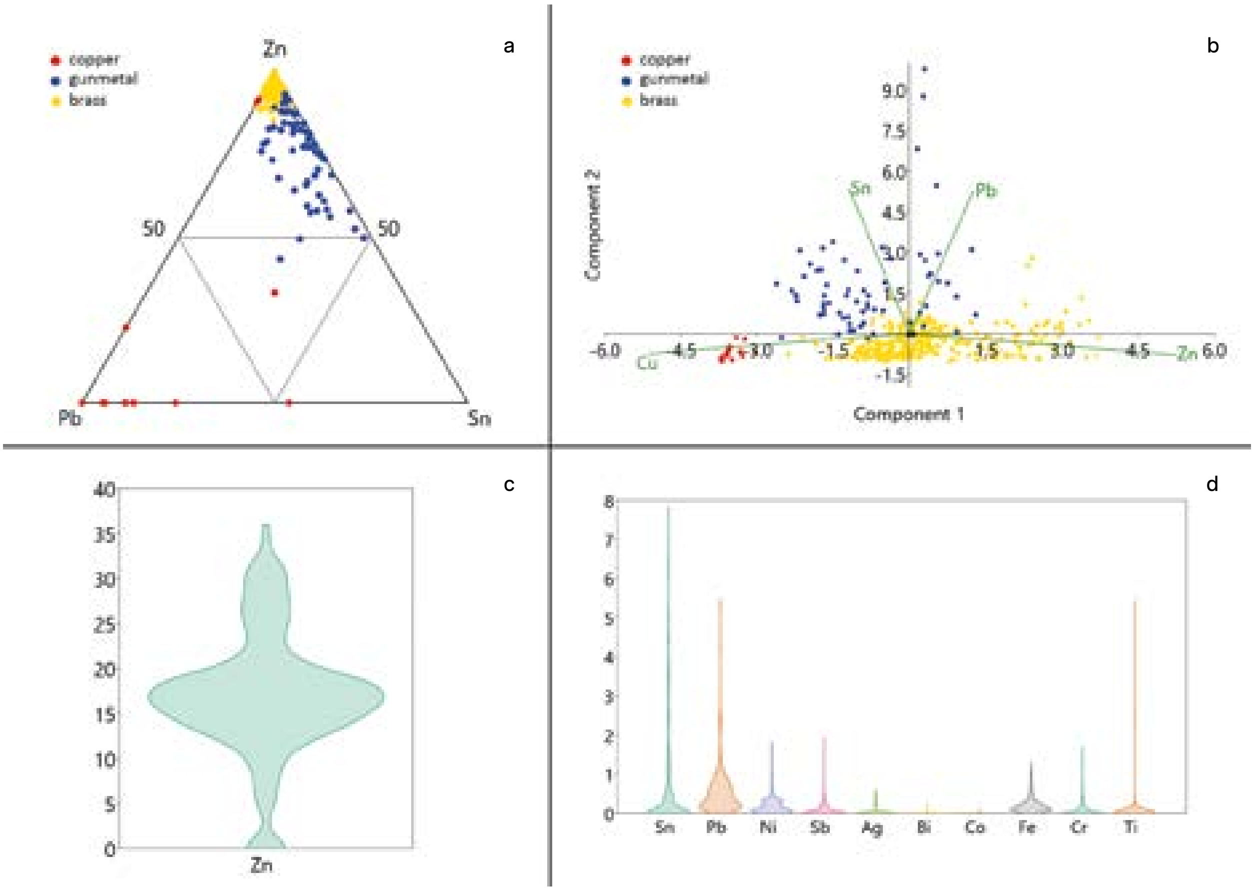

Fig. 2 General evaluation of pXRF analyses (in wt %) of copper-based artefacts (n = 415): **a** ternary plot of main alloying elements (Zn, Sn, Pb). – **b** scatter plot of PCA of main elements (Cu, Zn, Sn, Pb). – **c** violin plot of zinc content. – **d** violin plot of alloying and admixture elements, except zinc. – (Graphics M. Kmošek).

the collection from Pekařská Street at 3 %. The brass composition shows a maximum zinc content of 36 % and a multimodal composition with a main peak at 17 % and two other smaller peaks at 26.5 % and 30.5 % of zinc content (**fig. 2c**). These figures indicate the systematic usage of different types of brass. Their application for specific types of artefacts is investigated below. The minimum zinc content that allows the alloy to be called brass is not uniformly stated by the various authors. The maximum limit of historical brasses rarely exceeds 30 % (e. g. Morton 2019, 7; Cassitti 2021, 99; Bailey 2002, 13; Newbury et al. 2005, 81), although experiments in clay graphite crucibles and furnaces inspired by historical and archaeological evidence have shown the possibility of a higher proportion of zinc (Bourgarit/Thomas 2015, 260).

Gunmetal (copper alloyed with zinc and tin) is present at around 15 % of the collection. Compared to brass, gunmetal shows a generally lower amount of zinc in the alloy (average 12.5 %) and tin content is in the 1–8 % range (average 3 %). Gunmetal with the characteristics described above may also be referred to as »red brass«, i. e. brass with a low zinc content alloyed with small amounts of tin. The origin of gunmetal can be a result of intentional alloying or could be derived from recycling/mixing brass and tin bronze (lowering of zinc content, addition of tin).

Unalloyed copper (zinc below 3 %, tin below 1 %) occurs only in 5 % and seems to create a minor but specific group of finds. Tin bronze (7.5 % Sn, 0.1 % Zn) occurred in only one case – a ring with four spokes (inv. no. A452180; Kmošek/Procházka 2020, 32 tab. 2 fig. 2) and represents an isolated occurrence.

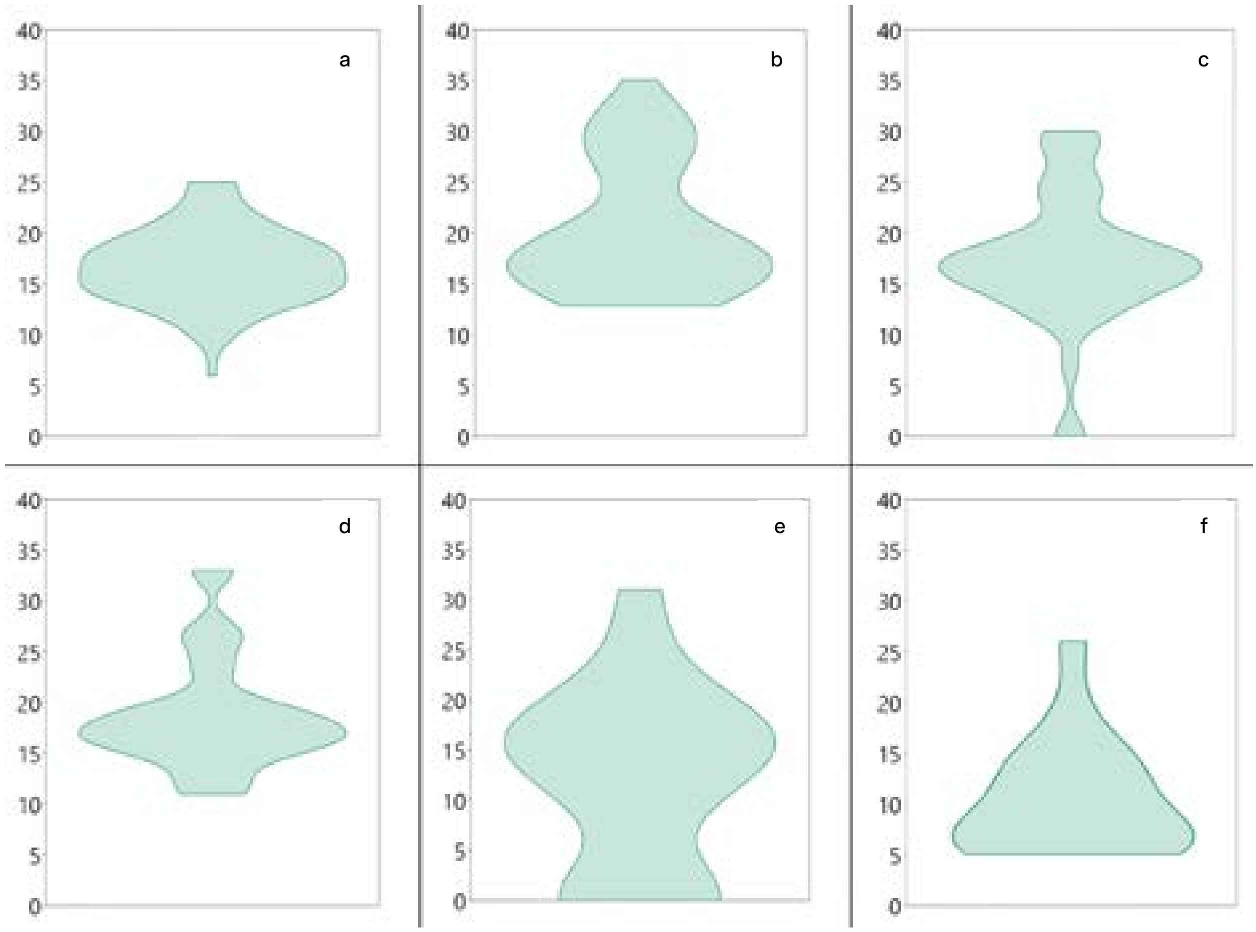

Fig. 3 Violin plots of the zinc content for specific types of artefacts (in wt %): **a** mounts. – **b** pins. – **c** hooks and eyes. – **d** belt segments. – **e** scrap sheets. – **f** buckles. – (Graphics M. Kmošek).

Evaluation of Specific Types of Artefacts

The evaluation of the elemental composition revealed significant differences between specific types of artefacts especially in terms of their alloying. For this more detailed evaluation, only large and consistent groups of finds were chosen: mounts, pins, hooks and eyes, belt segments, scrap sheets and buckles. The detailed commentary of the composition is given for each group below. Together, the results for these six types create a group of 271 analyses (65 % of copper-based artefacts) of the collection from Brno – Pekařská Street. The other groups of artefacts are either too small or too diverse to allow reasonable conclusions to be drawn in this type of evaluation. The evaluation is presented in the form of violin plots for the content of zinc (**fig. 3**) and other elements (**fig. 4**). More common ternary plots do not present the absolute values of elements but their proportions, which distorts the quantitative contents. Therefore, the results are presented in the form of a violin plot to show the full distribution of the data, which is usually multimodal. The content of zinc (**fig. 3**), tin and nickel (**fig. 4**) has the greatest significance for distinguishing different types of artefacts. The other elements (Pb, Sb, Ag) show relatively invariable concentrations and therefore less functional differentiation. For distinguishing specific admixtures and trace elements, more precise methods of bulk analysis would be needed.

Pins

Among dress accessories, pins are highly predominant, as mentioned above (more than 700 pieces; **fig. 5**). In general, pins are thin artefacts with a pointed end and a head at the opposite end. Their purpose is to hold pieces of cloth or clothing components together, especially headdresses, veils, etc. The types and shapes of pins are manifold and merit interest and investigation (Pratchett 2004; Caple

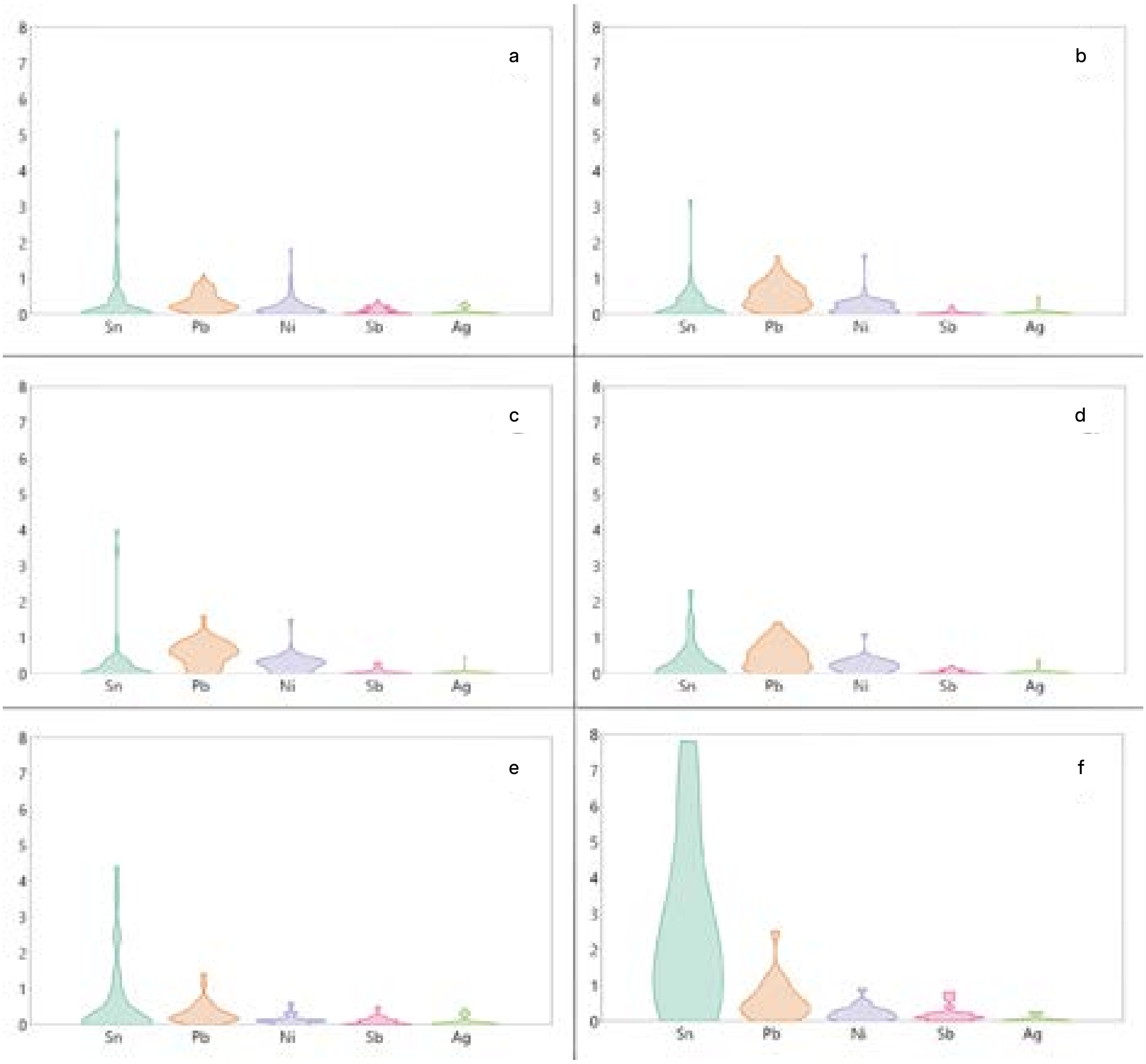

Fig. 4 Violin plots of admixture contents for specific types of artefacts (in wt %): **a** mounts. – **b** pins. – **c** hooks and eyes. – **d** belt segments. – **e** scrap sheets. – **f** buckles. – (Graphics M. Kmošek).

1986; Cassitti 2021). The collection from Brno–Pekařská Street registers 648 exemplars, which makes them the most abundant type of find. However, given their dimensions they are not the heaviest group (quite the opposite). There are pins of miscellaneous dimensions: length 1.29–7.81 mm, pinhead diameter 0.1–0.48 mm, shaft diameter 0.03–0.17 mm, weight 0.01–0.84 g. Considering the types of pins, they are mostly wound wire headed pins (WWHP), but also tin headed pins and rarely upset headed pins (in detail below).

The assemblage of pins from Pekařská Street is one of the largest in Europe, and similar finds from Western Europe date back to the Early Middle Ages. From the 14th century onwards, they become much more common (Egan/Pritchard 2002, 297–304; Krabath 2001, 190–196. 507–512; Ottaway/Rogers 2002, 2915–2916; Cassitti 2018, 99–100; 2021, 26–27). In the Czech lands and surrounding territories, they are commonly spread from the late 15th century. They were widely used in the Renaissance and Baroque era and were not replaced by modern forms before the 19th-century industrialisation (Omelka et al. 2011; Garbacz-Klempka et al. 2017, 251; Schlenker 2007, 51–54; Cassitti 2021, 163–167).

The material of pins (pXRF n = 48) is exclusively brass, mostly with a high zinc content. Pins have a minimum zinc content of 13 %, with the highest content reaching up to 36 % (**fig. 3b**). Their composition forms two peaks – more prominent at 17 % and smaller at 29 % of zinc, which suggests the use of two types of brass. The average zinc content of the

Fig. 5 Microscopic images of pinhead types (microscope Keyence VHX-5000, focus 50× and 20×): **a** WWHP variant A: inv. no. A452685/1. – **b** WWHP variant B: inv. no. A452685/5. – **c** WWHP variant C from three rings: inv. no. A452734. – **d** WWHP variant B with an irregularly cuboidal head from a ring: inv. no. A452342. – **e** upset headed pin: inv. no. A452491/67. – **f** tin headed pin: inv. no. A452302. – **g** semi-product of tin headed pin: inv. no. A452741. – (Photos M. Kmošek).

pins is 18.7 %, which Ch. Caple (1992, tab. 3) puts between the 15th and 16th centuries. In later centuries, the mean zinc content is gradually rising. A similar composition of the more prominent zinc content peak at 17 % is evidenced for pins in the Polish town of Puck (pow. Pucki/PL), where, in some cases, differences between the materials of the head and shaft were found (Garbacz-Klempka et al. 2017, 251).

The types of pins in the collection vary. The shafts of the pins are made exclusively from thin brass wire with a pointed end produced by grinding. The distinction between the different types is thus based solely on the construction of the pinheads. Three basic types are present – wound wire headed pins (n = 563; **fig. 5a-d**), tin headed pins (n = 24; **fig. 5f-g**) and upset headed pins (n =3; **fig. 5e**). A further 58 shafts with a pointed end are missing a head and cannot be identified by head type.

Wound wire headed pins are the most common type in the collection, as is usual considering contemporary finds (Caple 1986). Pins of this type have a tightly wound spiral or rings of brass wire stuck or crimped onto the top of the shaft. Three main variants (A–C) differentiated according to Ch. Caple (1992, 247–248) occur in the collection. The head is attached to the shaft by mechanical deformation especially in the case of variant B and C, but also A. In the case of variants A and B, the fastening could also be secured by a flux or adhesive. Both variants B and C (except for irregular shapes) were mostly made by compressing the head between a pair of hemispherical hollowed punches. Therefore, their difference is vague and insignificant, because it is derived from the size of punches compared to the size of the head. If the material of the head is sufficient, it creates a regular spherical head. If it is not sufficient, it does not fill the punches completely, thus creating a head of variant B. Therefore, the difference between variants B and C can be sometimes unclear.

Variant A (n = 158) has two twists of spiral wire stuck to the top of the shaft with a flux or adhesive and some mechanical securing (**figs 5a; 6a**). Variant B (n = 132) mostly has two twists of spiral wire loosely crimped to the top of the shaft forming a roughly spherical head (**fig. 5b**). In some cases (n = 31), the wire is not spiral, but consists of one or two rings secured to the top of the shaft. These heads composed of rings are mostly regular (n = 26), but sometimes also irregularly cuboidal (n = 5; **fig. 5d**), and are made without dies but by crude hammering. Variant C (n = 273) mostly has two twists of spiral wire tightly crimped to the top of the shaft forming a regular spherical head (**fig. 6b**). As in the case of variant B, some heads are composed of individual rings instead of spiral wire (n = 25). The number of rings creating the head is usually one or two, but in rare cases also three (**fig. 5c**).

Less frequent tin headed pins (**figs 5f; 6c**) are made using a completely different technique. A similar brass wire shaft was affixed by a spherical tin head cast on the top of the shaft. The heads are made of tin with only a low admixture of lead (0.2–0.3 %). The collection also includes a semi-product from the manufacture of tin heads (**fig. 5g**), which illustrates the process. The casting was made in a two-part mould (fins on the sides of the head) with at least two pairs of hemispherical head spaces connected by a quarter-circle runner. The position of shafts would be at a 90° angle. In this way, at least two pins could be secured by a tin head at once. After the casting, the runner was apparently usually removed, and the head could be mechanically rounded to remove the fins.

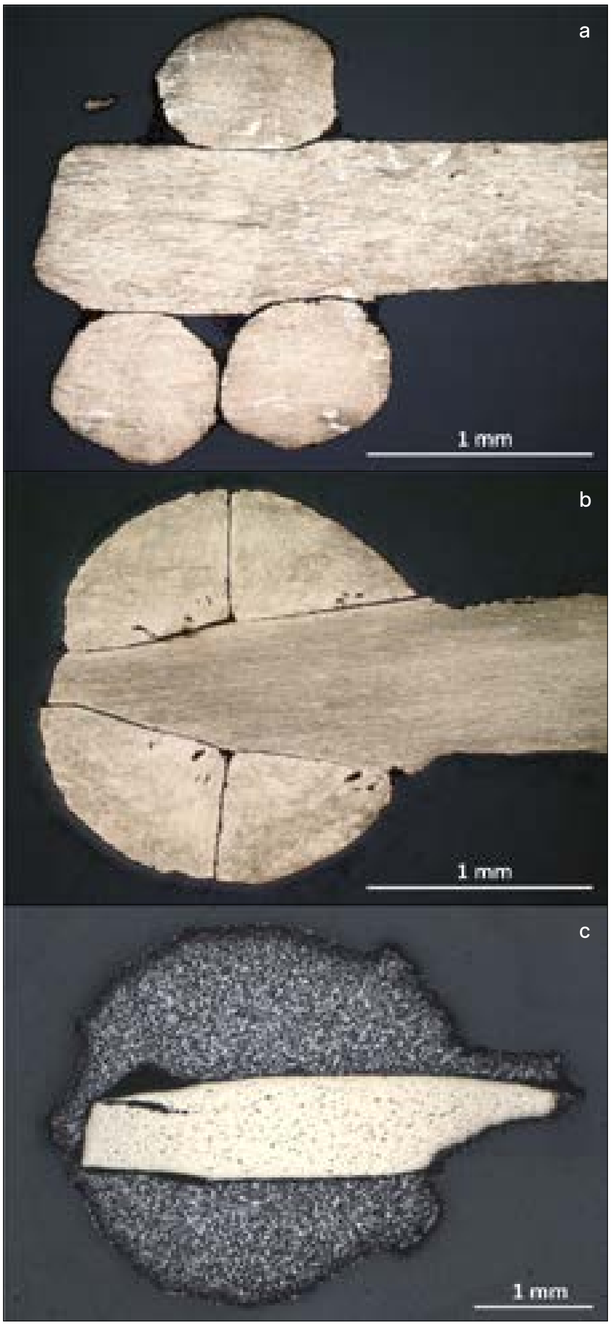

Fig. 6 Metallographic images of the microstructure of pinhead types (inv. no. A452491): **a** WWHP variant A. – **b** WWHP variant C. – **c** tin headed pin. – (Photos M. Kmošek).

Hooks and Eyes

Abundantly represented hooks and eyes (more than 260 pieces) were also used to connect different parts of the clothing. These were very common in the Late Middle Ages and Early Modern times. They were made from a single plain wire. The hooks are omega shaped with the ends bent into loops. The eyes also usually have ends with a pair of loops, and the bent middle closing part is sometimes hammered. In London, hooks and eyes are not mentioned until the end of the Middle Ages. They are also dated to the Renaissance in York (Yorkshire/GB), which is confirmed by finds from Luther's house in Mansfeld (Lkr. Mansfeld-Südharz/DE) in Germany (Krabath 2001, 196–204. 515–517; Ottaway/Rogers 2002, 2921;

Fig. 7 Photograph and metallographic image of lace chapes (inv. no. A452210). – (Photos M. Kmošek).

Schlenker 2007, 49–53; Šlancarová 2018, 99–100; Cassitti 2021, 27–28. 167–169).

Looking at the material composition of hooks and eyes (pXRF n = 44), they are a relatively inhomogeneous group, ranging from unalloyed copper to brass with a high zinc content (up to 30 %). Despite that, the most common material is again brass with around 17 % of zinc as usual (**fig. 3c**). Their composition is relatively similar to that of pins and belt parts (below), but with a greater degree of inhomogeneity. It seems that their production was mostly standardised, but some of them could be produced in a decentralised way.

Lace Chapes

From the same group of dress accessories, we cannot the forget tubular lace chapes, also represented in large numbers (79 pieces; **fig. 7**). They were made from coiled sheet metal. They were attached to the ends of laces, sometimes secured by a side hole. They also do not fully assert themselves until the Renaissance (Krabbath 2001, 227–229. 521–524; Ottaway/Rogers 2002, 2918–2921; Lungershausen 2004, 47; Schlenker 2007, 48–51; Sawicki 2021, 67–68. 219–226; Šlancarová 2018, 101). In London, lace chapes have been documented since the 13th century (Egan/Pritchard 2002, 281–290), a large collection is also known from Prague (Sawicki 2021, 209–217). Sheet lace chapes are made usually of brass (pXRF n = 13; 11.3–32.6 % Zn). Their microstructure shows heavily annealed brass with lead inclusions without much mechanical deformation (**fig. 7**). Heavy annealing can simplify the attaching of the artefacts to the lace end.

Mounts

Common finds also include many sheet mounts/appliques, exceptionally with preserved leather. Their usage was quite broad and they were applied to belts, pouches, clothes, but also to objects unrelated to human clothing, such as book bindings (e. g. Krabath 2001, 184. 501–502. 537–552; Egan/Pritchard 2002, 162–219; Sawicki 2017, 52–60. 165–195; 2021, 52–56. 155–171; Šlancarová 2018, 197–217; Cassitti 2021, 32–35. 152–159). We find close analogies to some of them (in the shape of a rose) in Luther's house in Mansfeld (Schlenker 2007, 34–44).

The mounts were formed from flat sheet metal by stamping, or more precisely by repoussé and chasing (the technique description in: Sawicki 2017, 25; Barčáková 2014). From the perspective of material composition, mounts (pXRF n = 97) form the most abundant and most consistent group. Their material is brass with a distinct single peak around 17 % of zinc (**fig. 3a**), which is also the most prominent one in the general evaluation.

Scrap/Semi-product Sheets

The assemblage from Pekařská Street also includes sheets that come from the manufacturing of mounts. They are either scrap (small irregular pieces) or semi-product sheets (partially finished mounts). The microstructure of the sheet (inv. no. A452201; **fig. 8**) shows significant annealing and subsequent heavy mechanical deformation. This indicates continuously processed sheet by heat and mechanical treatment. Scrap/semi-product sheets (pXRF n = 31) show a significantly different composition compared to mounts. They are often made of brass with a peak at 17 % of zinc and reaching up to 31 %. The difference is unalloyed copper, which was frequently used for their manufacturing besides brass (**fig. 3e**). This group is also distinguished by a low nickel content (**fig. 4e**). The unalloyed copper sheets were most probably used for the subsequent cementing of zinc after finishing the shape to create brass mounts in crucibles (see Newbury et al. 2005). Support for this hypothesis is the fact that we are missing any finished contemporary artefacts from unalloyed copper. This suggests the processing of copper sheets and manufacturing of brass mounts directly in Brno. The number of scrap and semi-products sheets indicates that there could be a coppersmith's workshop directly in the neighbourhood of the archaeological site in Pekařská Street, yet the extent of these activities is unknown.

Belt Segments

One of the most aesthetically pleasing artefacts in the assemblage is belt segments (pXRF n = 33) made merely of brass with a main peak at 17 % and with a zinc content range of 11–33 % (**fig. 3d**). This composition corresponds well with the results of an analysis of contemporary belt segments from Brno (Měchurová et al. 2014).

A remarkable group is represented by the parts of segmented girdles. Research has given them considerable attention, but we still occasionally encounter their interpretation as parts of book fittings/binding (e. g. Šlancarová 2018, tab. 16:9–16:11; 2019, 153; Lungershausen 2004, 93–94 pl. 19, 220–224). The correct interpretation was already given by N. Lithberg (1932) based on a large collection from the moat of Swiss Hallwyl Castle (ct. Aargau/CH). In the aforementioned layer 4a, a total of ten such fragments were found, probably all from the group of composite belts (metal combined with leather or fabric), which was proven in the assemblage in five cases. Therefore, they correspond to J. Harder's third variant (Harder 2010, 4). The collection consists of three horseshoe-shaped links, in two cases with attachment plates, a clasp with a hook (**fig. 10**) and finally six components of the clasp-frame fastening type (**fig. 9**). The clasp-frame type segmented girdles are decorated, except in one case, by pressed decoration with the motif of a hop leaf (or possibly branch with leaves). Therefore, they give the impression of a single workshop, although the decoration and quality of execution are not completely identical.

The segmented girdles became widespread in Europe. The hop leaf motif is considered typical of Central Europe in the years 1515–1540. Its first use is associated with the Augsburg engraver Daniel Hopfer (1471–1536), who had it in his crest granted in 1524

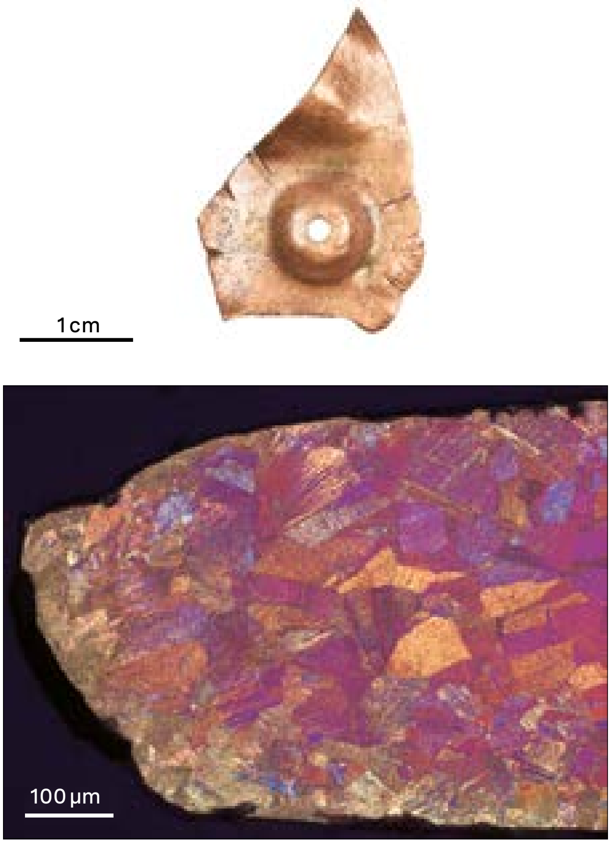

Fig. 8 Photograph and metallographic image of a semi-product sheet (inv. no. A452201) with perforated half-hemisphere protrusion. – (Photos M. Kmošek).

by Charles V (1519–1556). The hop branch/leaf motif was used in different variants on segmented belts, including all-metal specimens (compared to composite belts) also known from Brno (Harder 2010, 7; Krause 2011/2012, 54; Selucká et al. 2002; Měchurová et al. 2014, 288–292). In Bohemia, segmented girdles became very popular in the 16th century with different variants of the hop leaf motif (Musil 2011; 2012; Čapek 2016; Sawicki 2021, 58–60. 186–191). It is interesting that this motif is still missing from the published Prague collection (Sawicki 2021, 183–191). The depiction of the hop leaf on artefacts from Pekařská Street corresponds to the basic concept of this motif, which is preserved, for example, on the armour of Otto Henry (1502–1559) made in Augsburg in 1516, probably with the participation of D. Hopfer (Krause 2011/2012, 61 fig. 5). The use of ring-shaped (and thus also horseshoe-shaped) segments (i. e. for hanging various objects) within a composite belt made of metal and leather is clearly visible in a painting by Hans Hug Kluber from 1559 (Flückiger 2017, 417 fig. 8).

A specific group of segmented girdles bears a distinctive decoration by mechanical pressing. Copper-based (commonly brass) sheet metal was adjust-

Fig. 9 Two parts of a segmented girdle (inv. nos A452158, A452159) with flat pressed decoration and microscopic comparison of their decoration. – (Photos M. Kmošek).

ed into the desired shape and decorated by frequently complex decoration. Pressing was accomplished with dies, which allowed rapid mass production of identical decorations. There are two basic types of pressed decoration on segmented girdles from Brno – Pekařská Street. Both use a similar technique involving the mentioned dies. The first type has a more or less flat decoration (**fig. 9**), while the second type is distinguished by the relief components of the decoration (**fig. 10**). For the flat decoration, just one die is needed to decorate the front side of the sheet. In the case of more relief decoration, two complementary dies are required – a lower die for relief protrusions from the back side of the sheet and an upper die for the front detailed decoration as above.

Pressing decoration was apparently created before the assembly or folding of sheets. Especially in the case of flat decoration, specific flaws are present. Pressing decoration is usually positioned on the base sheet asymmetrically and non-centrally. Another common flaw is unequal imprint on different parts of the sheet, caused by uneven base/sheet during pressing. These defects, which are particularly common on flat pressed decorations, demonstrate mass production with little control. In the case of relief pressed decoration, more attention must be paid to the production process and these artefacts thus do not show the mentioned flaws with such a frequency.

The segmented girdles from Pekařská Street probably belong in all cases to the group of composite belts which combine different materials (metal with leather or fabric; see above and Harder 2010, 4). The pXRF analyses proved that segmented girdles, especially separate parts of horseshoe-shaped links, were also made from different materials from the point of view of copper alloy composition. The two-side attachment plates were made from exactly the same material, while the central horseshoe-shaped links are made from a distinctly different material (**fig. 11; tab. 2**). This duality in material composition could indicate the mass production of separate parts of segmented girdles. Considering such mass production, the assembling of the separate parts did not have to take place where the parts were produced.

Fig. 10 Segmented girdle (inv. no. A452156) with relief decoration (three central protrusions) and microscopic image of its decoration. – (Photos M. Kmošek).

Buckles

The large number of buckles in the assemblage (69 specimens including fragments) is very diverse in shape. They include one-piece specimens with a circular, oval, square, or pentagonal frame, and the shape of the letter D is also represented. There are also two-part buckles, divided by a bar, in the shape of a simple oval or a figure eight. Only one of them has a preserved attachment plate. These are mostly small artefacts, usually corresponding to the width of a strap of 0.6–2.5 cm, whereas larger ones with a width of around 4.5 cm are rare (Zůbek 2002). Their shape corresponds to other contemporary collections (e. g. Egan/Pritchard 2002, 50–123; Krabath 2001, 131–158. 496–500; Lungershausen 2004, 26–38; Sawicki 2021, 95–125; Šlancarová 2018, 154–196). The material composition of buckles (pXRF n = 18) is noticeably distinct compared to all other evaluated groups. They are made mostly from gunmetal (or so-called red brass) with a low zinc content (**fig. 3f**; 7 % zinc) and a tin content of up to 7.8 % (**fig. 4f**). This material difference from other groups is striking and may be the result of an intentional material selection (red brass) or different manufacturing effects (lower price, local production, recycling of different materials).

Jewellery

Jewellery is represented by simple rings, pendants and chains from coiled wire. The rings were made from rods of various cross-sections, strips or wires. Exceptionally they carried a plate or, in the case of wire pieces, a bed for the stone. The only one bearing a label with the letter »e« in Gothic script was made of lead and tin alloy, the others of copper alloys. Altogether, seven rings analysed by pXRF were made of brass (four pieces, 9.3–20.2 % Zn, <0.8 % Sn) and gunmetal (three pieces, 11.9–18.8 % Zn, 1.3–4.4 % Sn). This composition is closely comparable to copper-based late medieval rings from Krakow in Poland (Głowa/Garbacz-Klempka 2010, 100–103 tab. 1).

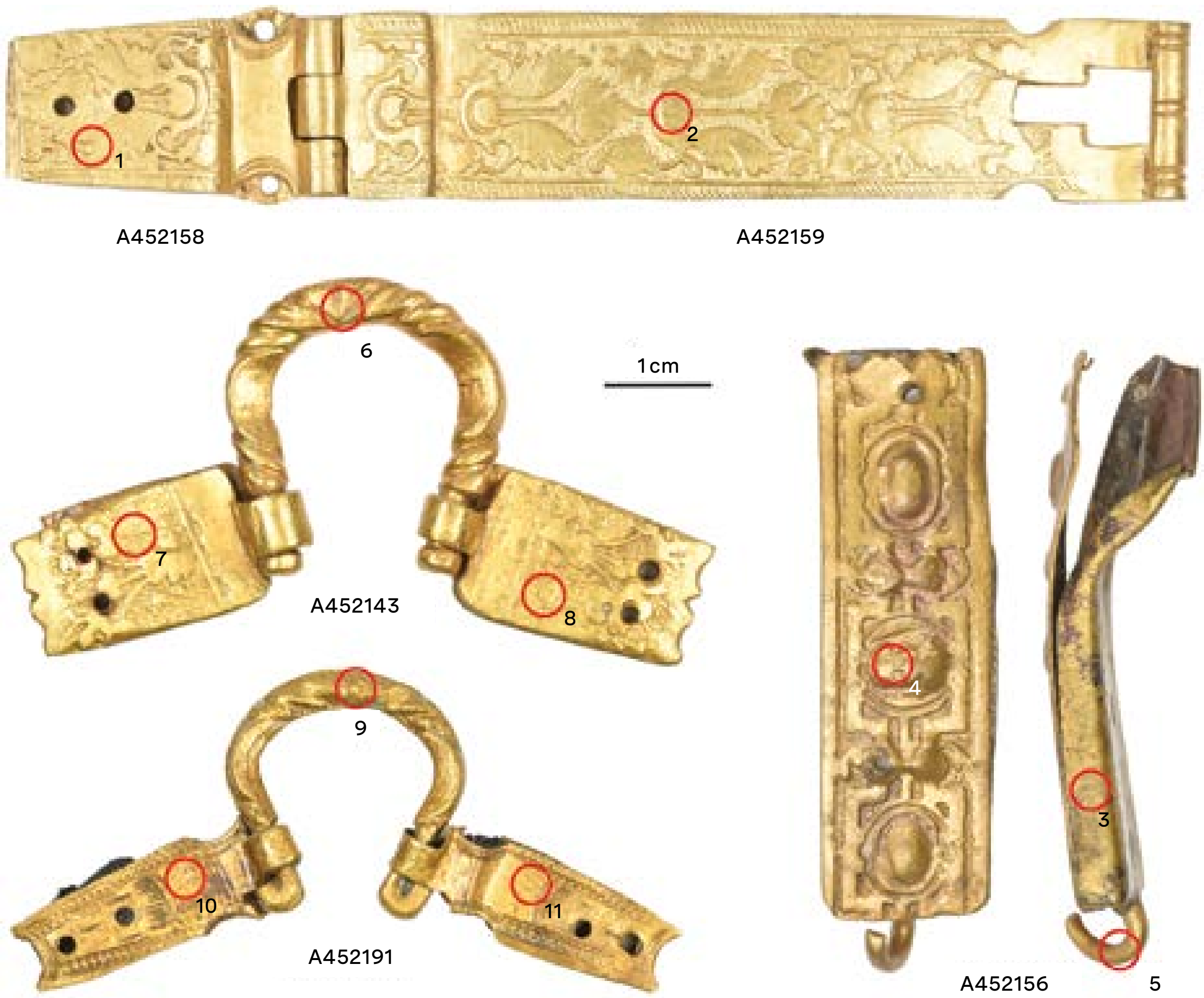

Fig. 11 Composite segmented girdles with positions of the pXRF analysis of their different parts. – (Photos M. Kmošek).

Rings from Pekařská Street were inexpensive products used by the common people of the city (with numerous analogies Krabath 2001, 121–128. 492–495; Egan/Pritchard 2002, 325–335; Lungershausen 2004, 49–51; Miścicki 2017, 227; Głowa/Garbacz-Klempka 2010; Trawicka 2010, 110; Šlancarová 2018, 120–134). Pendants are mainly represented by a few pieces with specific shapes. The most prominent pendant has the shape of a running animal in relief, perhaps a deer or a goat, with a loop for hanging on the back. The second is a miniature crossbow. Both also made of tin-lead alloy with a dominance of tin (Macháňová et al. 2013). Similar tin-lead alloys were not an exception in Late Middle Ages jewellery (e.g. Głowa/Garbacz-Klempka 2010, 106–107). The crossbow pendant has more analogies – it could be associated with archery and crossbow guilds (Macháňová et al. 2013; Sawicki 2014, 19–21; Šlancarová 2018, 87). Chains serving mainly as necklaces include several types differentiated by the links used – made of single wire, variously shaped, doubled, braided or coiled wire. They are made of average and high-zinc brasses (pXRF n = 11; 11.8–36.0 % Zn). Their use shows a boom in the Late Middle Ages and the Renaissance (Egan/Pritchard 2002, 318–320; Schlenker 2007, 47–49; Sawicki 2021, 70–71. 247–251; Šlancarová 2018, 70–76).

Individual Artefacts

Other artefacts are only present individually in the assemblage. Most of them become more common at the turn of the Middle Ages and the Renaissance, especially ear spoons, tweezers, thimbles and faucets. The stylus and fittings of a book belong to the domain of spiritual culture (e.g. Krabath 2001, 98–113. 481–486. 525; Egan/Pritchard 2002, 379–383; Ottaway/Rogers 2002, 2739–2741. 2932. 2934; Konczewska/Konczewski 2004; Lungershausen 2004, 27. 77–78. 100–104; Schlenker 2007, 71; Krzywdziński 2013, 129; Miścicki 2017, 211. 215; Cassitti 2018, 98–

inv. no.	part of the girdle	position	Cu	Zn	Pb	Sn	Ni	Sb	Co	Fe	Cr
A452158	attachment plate	1	79.2	18.1	0.98	0.44	0.34	0.15	0.00	0.76	0.04
A452159	frame plate	2	79.4	18.0	0.94	0.43	0.35	0.13	0.00	0.76	0.00
A452156	back plate	3	65.9	33.0	0.89	0.00	0.12	0.01	0.00	0.01	0.07
	front plate	4	81.1	17.1	1.07	0.06	0.31	0.00	0.00	0.22	0.14
	hook	5	82.2	16.3	0.53	0.57	0.24	0.00	0.01	0.12	0.05
A452143	horseshoe-shaped link	6	87.4	11.6	0.57	0.00	0.14	0.04	0.00	0.18	0.01
	left side attachment plate	7	83.0	16.2	0.09	0.27	0.31	0.01	0.00	0.06	0.04
	right side attachment plate	8	83.2	16.0	0.08	0.27	0.31	0.00	0.01	0.06	0.03
A452191	horseshoe-shaped link	9	80.7	17.5	0.86	0.47	0.32	0.03	0.00	0.11	0.04
	left side attachment plate	10	80.8	18.0	0.43	0.14	0.17	0.03	0.02	0.25	0.17
	right side attachment plate	11	80.6	18.3	0.43	0.14	0.18	0.03	0.03	0.19	0.07

Tab. 2 Results of the pXRF analysis of different parts of composite segmented girdles (in wt%).

99; 2021, 79–80. 1243–1249). Therefore, it shows a typical spectrum of finds of non-ferrous artefacts from the end of the Middle Ages and the beginning of the Modern period. They are all made from brass with average and high zinc content (14.6–33.1 % Zn). Clearly older is a gunmetal seal matrix (5.7 % Zn, 2.8 % Sn) of the 14th-century burgher Conrad Ollman in writing.

Conclusion

The archaeometallurgical investigation of finds from Brno–Pekařská Street revealed new information especially about the elemental composition of copper-based finds. The predominance of brass was detected as in other similar collections of that period. The gradual predominance of brass over copper throughout the Middle Ages, especially in Central Europe (Heyworth 2002, 391; Morton 2019, 1–126; Cassitti 2021, 99–102), continues in the case of the finds from Pekařská Street and persists to the present day. Simultaneously with the finds from Brno–Pekařská Street, quite a number of written sources on the mining and production of metals appeared in Europe, especially a comprehensive work by Georgius Agricola (1556). The contemporary written and archaeological sources encompass also brass making technology (Martinon-Torres/Rehren 2002).

There is evidence of non-ferrous crafts in written sources involving metalworkers in medieval Brno. But only some specialisations are present, mostly goldsmiths, potters and pewterers. Copper-based crafts are not massively present in the sources, just in some examples of bell-makers, coppersmiths and girdlers. This corresponds to the rather rare evidence of tools and structures for non-ferrous production found so far in Brno. The metal production existed here, but not to a significant extent. In the field of metalworking production, Brno probably had only a regional significance due to the small number of specialisations and manufacturers represented.

The comparison of the chronologically quite similar assemblage from Pekařská Street with other analysed medieval collections has its complications. Their chronological focus is mostly older and more disperse (e.g. Dungworth/Egan 2005; Bourgarit/Thomas 2012; Carrera 2018; Bottaini et al. 2022), which is problematic considering the gradual development of copper alloys during the Middle Ages and the Modern period (Dungworth/Egan 2005). For example, in Braunschweig in Germany the zinc content does not exceed 25 %, mostly not even 15 %. A zinc content around 20 % is quite rare in Puck in Poland (Lungershausen 2004, 150 tab. 13; Garbacz-Klempka et al. 2017, 250 tab. IX.5). The zinc content in the ten analysed late medieval brass objects from Leopoli-Cencelle (prov. Viterbo/IT) in Italy did not exceed 23.7 % (Gaudenzi-Asinelli/Torres 2016, 603 tab. 3). As in the publication of M. Heyworth (2002), a limited range of compositions was detected for specific types of artefacts (alloy brooches, buttons, and pins), even if the types are somehow different than those in the case of Brno–Pekařská Street. In the assemblage from Brno – Pekařská Street, a peak of 17 % zinc is evident, but a composition with over 30 % of zinc is also quite frequent. This indicates the distinct standardisation and perhaps also the general growth of the zinc content during the Late Middle Ages and especially the Early Modern period.

The prevalence of the usage of brass throughout the Middle Ages and the Modern period and finally to the present is understandable. Brass has favourable mechanical and chemical properties for casting and hammering. The material is malleable, ductile and has a low melting point while preserving high workability. Its colour also has a significant impact – it has a bright, gold-like appearance which can deceive the eye of the unknowing. Compared to present-day standards (e. g. brass CuZn37), the situation during the Middle Ages and the Modern period was not that sharp and clear. There was more likely an inclination towards an alloy recipe than a standard composition with sharp boundaries. During the Late Middle Ages, the term »brasse« was used for all copper-based alloys (Blair et al. 1986, 85). The name »brass« was used alongside the terms »latten« and »maslin«, but not there was little agreement as to their exact composition.

The material from Brno – Pekařská Street more likely shows a compositional range with specific inclinations, for example three peaks of the zinc content in brasses. There does not seem to be an exact recipe, just a general range creating large vague clusters. This can also be partially caused by reprocessing the material (recycling by remelting or use of scrap metal). Apparent in the collection from Brno – Pekařská Street is the existence of the most common brass composition with ca. 17 % of zinc, with slight variations. In addition, there are several other alloys in use for specific types of artefacts. This phenomenon is valid for the collection in general and for all evaluated specific groups, except buckles. Buckles form an isolated group of finds because they are most frequently made of gunmetal.

The frequent material homogeneity of the group can point out to large-scale production and trade in specific artefacts. This can be valid especially for pins with a homogenous composition, with brasses generally having a high zinc content. A somewhat similar composition can also be found with belt segments and hooks and eyes, albeit with a greater dose of inhomogeneity. On the other hand, inhomogeneity can possibly point to disperse or local manufacturing.

Mounts show the use of only average brass (17 % Zn). That is mostly similar to scrap/semi-product sheets made of average brass and unalloyed copper, also with a low nickel content. The character of these finds in accordance with their specific composition can point to a local origin/processing of these finds. The sheets from unalloyed copper were apparently subsequently cemented by zinc to create brass mounts. From the assemblage, copper sheet scraps and semi-products are possibly evidence of copper smithing in the close neighbourhood of the site, thus local metalworking in Brno.

Most other artefacts (gunmetal buckles are questionable) were probably produced in some other metalworking centres, most probably from abroad, and brought to the city by trade. They could also be transported to Brno in the form of semi-finished products and only assembled into final products in the city. Buckles are a material exception in the assemblage (gunmetal instead of most common brass). The manufacure of buckles was clearly based on the use of different materials from those generally used in the Late Middle Ages and the Early Modern period. But the reason for this is not easily/possibly answerable on the basis of artefacts from Pekařská Street. Based on decoration, segmented girdles have a connection to Augsburg and were most probably produced abroad. It is surprising that pressed decoration is not present in the collection from Nowy Targ in Poland (pow. Nowotarski/PL; Sawicki 2017, 25), which is in other respects very similar to the finds from Brno – Pekařská Street.

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Zusammenfassung
Résumé

Städtische Technik auf Kupferbasis in Brno. Archäometallurgische Analyse der Funde aus der Pekařská Straße in Brno

Der Artikel präsentiert die wichtigsten Ergebnisse der 417 archäometallurgischen Analysen des vielfältigen Fundkomplexes (1504 Stücke) von Nichteisenmetallartefakten, die während der Rettungsgrabung im Jahr 1989 in der Pekařská Straße in Brno (okr. Brno-město/CZ) geborgen wurden. Die Fundmenge, die vom späten 15. bis in die erste Hälfte des 16. Jahrhunderts datiert, besteht hauptsächlich aus Trachtbestandteilen. Zudem umfasst sie Schmuck, persönliche Hygieneartikel sowie andere Gegenstände der Haushaltsausstattung und spirituellen Kultur. Zur Untersuchung wurden mehrere Methoden verwendet, darunter pXRF, optische Mikroskopie und Metallographie mit SEM/EDS. Die allgemeine Materialzusammensetzung zeigt eine dominante Verwendung von Messing mit einem Hauptpeak bei 17 % Zink und einem maximalen Anteil von 36 %, gefolgt von Rotguss (Zinnmessing), gelegentlicher Anwesenheit von unlegiertem Kupfer und Zinnbronze. Die Ergebnisse zeigten unterschiedliche Strategien der Materialnutzung für die Produktion bestimmter Gruppen, z. B. das Vorkommen von Hochmessing für Stecknadeln, Rotguss für Schnallen und unlegiertem Kupfer für Halbzeuge.

Technologie urbaine à base de cuivre à Brno. Analyse archéométallurgique des découvertes faites à Brno - rue Pekařská

L'article présente les principaux résultats se basant sur 417 analyses archéométallurgiques d'un ensemble de différents objets (1504 pièces) métalliques non ferreux révélés lors des fouilles de sauvetage dans la rue Pekařská à Brno (okr. Brno-město/CZ) en 1989. La plupart des trouvailles date de la fin du 15e jusqu'à la première moitié du 16e siècle, et se compose principalement d'accessoires vestimentaires, mais aussi de bijoux, d'articles d'hygiène personnelle et d'autres objets de culture domestique et spirituelle. Plusieurs méthodes ont été appliquées pour l'investigation, y compris pXRF, la microscopie optique et la métallographie avec SEM/EDS. La composition générale des matériaux montre une présence dominante du laiton avec un pic principal de Zn de 17 % à 36 % maximum, suivi du bronze à canon (laiton à l'étain), ainsi qu'une présence occasionnelle du cuivre non allié et du bronze à l'étain. Les résultats ont montré différentes stratégies d'utilisation du matériel pour la production de groupes spécifiques, par ex. la présence du laiton de haute qualité pour les broches, du bronze pour les boucles et du cuivre non allié pour les produits semi-finis.

Schlüsselwörter
Mots-clés

Brno / Spätmittelalter / frühe Neuzeit / Nichteisenmetalle / Messing / Bronze / Kupfer / Elementzusammensetzung / pXRF / Metallographie
Brno / Bas Moyen Âge / début de l'Époque moderne / métaux non ferreux / laiton / cuivre / composition élémentaire / pXRF / métallographie