

# From Production to Sales. Non-Ferrous Metalworking in Late Antique and Early Byzantine Ephesus

This paper highlights the preliminary results of the ongoing research project »Non-ferrous metalworking in Byzantine Ephesus«<sup>1</sup>. Archaeological data indicating metalworking activity was collected from older and recent excavations, thus 14 sites dating from the 4<sup>th</sup> to the 10<sup>th</sup> century, mainly located in the upper city, were included in the research. However, the current study focuses on the archaeological finds and features of the Late Antique and Early Byzantine periods. The studied material comprises over 800 fragmented and fully preserved crucibles, casting moulds, slags and copper alloy objects which can be linked to metalworking activities. Our scientific evaluation is based on two research methods. One is the traditional archaeological method, which deals with the interpretation, dating and classification of the objects and their find context. The other research direction entails analytic methods of the natural sciences, such as the examination of precision forging technologies with optic microscopy and material analyses of selected finds with scanning electronic microscopy (SEM)<sup>2</sup>, X-ray fluorescence analyses<sup>3</sup> and thin section analyses<sup>4</sup>.

A wide range of general and specialised metalworking professions are known from Early Byzantine literary sources<sup>5</sup>, yet we know little about their actual activity and organisational structure<sup>6</sup> at the time. Attempts have been made to match excavation results – mainly dating to the Roman Imperial period – with theoretical models of (the) Roman economy<sup>7</sup>. However, we lack such studies with regard to the Byzantine period. The main reason for this could be that the places of production are rarely found and the archaeological remains (e. g. badly preserved crucibles, scrap metal, iron tools) which indicate metalworking activity are hard to recognise and interpret. Besides the well-known artisans' workshop in the Crypta Balbi at Rome – dated to the 7<sup>th</sup> century<sup>8</sup> – barely any other early Byzantine metal workshop using non-ferrous metals has been found, excavated or published<sup>9</sup>.

The localisation of such workshops is based primarily on comparative studies about the distribution, typology and artistic style of precious metal and copper-alloy objects<sup>10</sup> and secondly on sporadically found matrices used for sheet metal work and casting moulds<sup>11</sup>. Accordingly, several seden-

- 1 The project »Buntmetallverarbeitung in Ephesos in byzantinischer Zeit« is conducted by the Römisch-Germanisches Zentralmuseum in cooperation with the Österreichisches Archäologisches Institut – Österreichische Akademie der Wissenschaften within the framework of the author's dissertation at the Universität Wien.
- 2 More than 30 samples of molten metal pieces preserved on the exterior or interior side of crucibles from various sites were taken for SEM-analyses, which were performed in the laboratory of the Vienna Institute for Archaeological Science by M. Mehofer.
- 3 XRF-analyses of numerous metal finds were carried out at the place of their storage, in the Ephesus Museum, and the depot of the ÖAI-ÖAW in Selçuk by M. Schreiner and M. Melcher, Akademie der Bildenden Künste Wien (Institut für Naturwissenschaften und Technologie in der Kunst), using both a handheld EDXRF (type xSort) and a micro X-ray fluorescence spectrometer ( $\mu$ -XRF, COPRA), and by D. Oberndorfer, ÖAI-ÖAW (Restoration Laboratory), using a handheld spectrometer (Olympus Delta DP-6000-CC).
- 4 In order to establish possible (technological) connections between the sites where non-ferrous metalworking could take place in the Early Byzantine Period, samples of crucibles and casting moulds were taken. The analyses have been carried out by R. Sauer and J. Erci in collaboration with the laboratory for archaeometry at the ÖAI-ÖAW.
- 5 See detailed summary about metalsmiths in written sources from the Early Roman until the Early Byzantine Period: Gummerus, *Goldschmiedegewerbe* 134f. 148-150. – Cf. Petrikovits, *Handwerk* 64f. 83-119 List 1 and 119f. List 2. – Petrikovits, *Handwerk II* 292-295. 295-306 List 1-4 (focusing on late antique literary sources). – Cf. Ruffing, *Handel und Handwerk* 39-51. 114f. 120. 125. 134f. focusing on specific craft specializations: 395-839.
- 6 Concerning the organisation of craftsmen (with special regard to metalworkers) based on literary sources: Drexhage/Konen/Ruffing, *Römische Wirtschaft* 110-112. – Hawkins, *Urban Economy* 66-68. – On archaeological and written sources:

- Drauschke, *Buntmetallverarbeitung 797-799*. – Bosselmann-Ruickbie/Fourlas/Greif, *Gold- und Silberschmiedehandwerk 801-803* and focusing on the goldsmiths working for the imperial court in Constantinople: Stolz, *Jewellery* 33f. 37.
- 7 Graf, *Metallwerkstätten* 3f. 6f.
- 8 This workshop specialised in the production of male and female clothing accessories and military equipment; recently: Ricci, *Luxury Goods* 2.
- 9 Major sites with archaeological proof of early Byzantine metal workshops or metalworking activity: In the residential area of the Lower Town in Justiniana Prima, numerous tools, casting moulds and matrices indicate metalworking activity in the 6<sup>th</sup> c. settlement (Ivanišević, *Caričin Grad 711-723*). In the area of the Athenian Agora, several »foundries« (dating from the 4<sup>th</sup> to 6<sup>th</sup> c.) could be identified (Mattusch, *Athenian Agora 368-374*). Small crucibles and casting moulds used in jewellery production are known from the Demetrios Basilica and the Ancient Agora in Thessaloniki (Antonaras, *Thessaloniki 25*, especially n. 96 and 97). From the underwater excavations at Abuquir (20 km from Alexandria) came glass as well as metallic raw materials (copper and gold ingots). Based on literary sources, the finds may be connected with the precious metal workshop situated in the pilgrim shrine of Menouthis (Stolz, *Kanopos/Menouthis 201f. 205f.*). In the workshop in Elephantine (near Aswan), specific metal vessels were produced, (primarily) for export, in the 5<sup>th</sup>-6<sup>th</sup> c. (Drauschke, *Elephantine 223-225*). Another workshop was reported from the urban area below the acropolis of Pergamon which produced belt buckles and jewellery (Gaitzsch, *Eisenfunde 91 n. 843f.*). Finally, the 2000 belt buckles and several casting moulds from Tralles should be mentioned, which suggest the possibility of local and even export production (Lightfoot, *Buckles 81 n. 6*).
- 10 See summary with regard to the different approaches and the state of research: Stolz, *Jewellery* 33f.
- 11 Schulze-Dörlamm, *Schnallen 2*, 303. – Davidson, *Corinth 308f. cat. 2671*. – Cf. Bosselmann-Ruickbie, *Schmuck 81 fig. 72 a-b*.



**Fig. 1** Map of Ephesus with locations of major early Byzantine workshops/metalworking activities. **1** Workshops in Terraced House 2: Room 46 and T III/2. – **2** Area directly behind the Nymphaeum Traiani. – **3** Door openings of tabernae on north side of the Embolos. – (Map ÖAW-ÖAI, Ch. Kurtze).

tary, perhaps even specialised, metal workshops might have functioned in the Byzantine Empire. These most likely produced metalwork of basic to medium quality, and followed an interregional style influenced by the central workshops in Constantinople<sup>12</sup> on one hand and satisfied the needs of local or even neighbouring customers (within or perhaps even outside the Empire) on the other<sup>13</sup>.

The aim of the present project is to examine specific areas of Ephesus where metalworking most likely took place in the Byzantine period; primarily with the help of archaeological finds and features in order to gain a better understanding of the role this craft played in the city's life.

The focus of the study is on the non-ferrous metal workshops in the Terraced House 2 (hereafter TH 2) excavated in Ephesus between 1980 and 1984<sup>14</sup> (fig. 1). In addition, the results of more recent excavations, e. g. along the Embolos street (Nymphaeum Traiani, tabernae) and at the south-eastern border of the city (Magnesian Gate<sup>15</sup>), divulged substantial pieces of information.

As we are studying the possible reasons for the occurrence of metalworking in the TH 2 and along the Embolos, two major factors should be mentioned. An earthquake and series of earthquakes hit the city in the 3<sup>rd</sup> and 4<sup>th</sup> centuries, respectively. Perhaps as a result of these, extensive repairs and construction measures were concentrated in the area of the Embolos at the end of the 4<sup>th</sup> and beginning of the 5<sup>th</sup> century<sup>16</sup>. The TH 2 was so severely affected that it never regained its original function as the residence of the upper social classes<sup>17</sup>. The transformation of this formerly prominent building complex into a quarter for artisans probably started at the latest in the 4<sup>th</sup> century with the installation of the first mills<sup>18</sup>, which was followed by establishing metal workshops around the 5<sup>th</sup> century<sup>19</sup> and a stone processing facility at the end of the 6<sup>th</sup> or beginning of the 7<sup>th</sup> century<sup>20</sup>.

The finds which prove that various metalworking processes took place in the workshops are from two places within the north front of the TH 2: room 46 (hereafter R 46) and the room behind taberna III (hereafter T III/2) and, to

12 Stolz, *Jewellery* 33. – For further interpretative possibilities with regard to the places of production and identification of »Byzantine« objects, see: Daim, *Gürtelgarnituren* 81. – Daim, *Belt Ornaments* 61.

13 Bühler, *Metalwork* 231.

14 Vetter, *Grabungsbericht* 218f. 221f.

15 The deposited waste material of a metal workshop (over 110 fragments of crucibles with added outer layer – see n. 22 – and preserved molten metal pieces) and a kitchen was excavated in 2009 outside the city walls at the southern tower of the Magnesian Gate (Sokolicek, *Magnesisches Tor* 369. 380f.). A complete evaluation of the archaeological finds and features is currently in progress. Our special thanks to A. Sokolicek for placing the material at our disposal.

16 An inscription plate announces the decree of the emperors Valens, Valentinian I and Gratian (from the year 370/371) in which the renovation of specific public buildings, especially the city walls, is ordered (Ladstätter, *Hanghaus* 2, 29-31). These undertakings could have been necessary because of the damage caused

by the earthquake series in the 4<sup>th</sup> c. However, a chronological correlation between archaeologically-identified damage, repairs and the edict is yet to be proven; for a more detailed discussion about the topic see Ladstätter, *Hanghaus* 2, 34-41. – Pülz, *Stadtbild* 546-552.

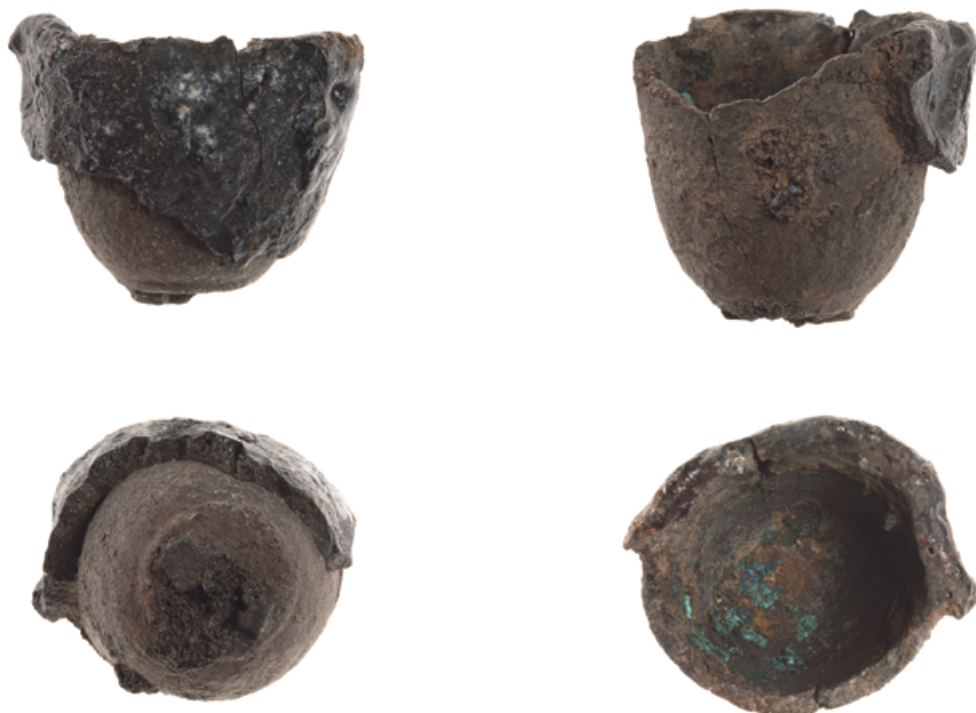
17 Ladstätter, *Hanghaus* 2, 38f.

18 Wefers, *Mühlen* 115.

19 Possibly one of the first mills was installed in room 46 (the same room where a later metal workshop would be located) between the third quarter of the 3<sup>rd</sup> and 4<sup>th</sup> c., but abandoned around the year 400 (Wefers, *Mühlen* 115). It is probable that the metal workshop was installed during the following century. The uncertainty of the relative and absolute chronology of the rooms and workshops is due to the fact that earlier excavations laid lesser emphasis on the stratigraphy of the TH 2 as well as the late antique and early Byzantine building structures and modifications, including the context of the archaeological finds, cf. Ladstätter, *Hanghaus* 2, 13f.

20 Ladstätter, *Steinsäge* 58.

**Fig. 2** Ephesus, Terraced House 2. An almost fully-preserved crucible from metal workshop in R 46. – (Photo ÖAW-ÖAI, N. Gaul).



a lesser extent, from the adjoining rooms and structures<sup>21</sup>. Both rooms measure approximately 3.0 m × 4.0 m. The finds of the workshop in R 46 consist of almost 100 fragments, fully-preserved crucibles and casting moulds, more than 150 copper-alloy objects, which represent the raw material, scrap metal pieces and semi-finished products of the workshop, and about 50 iron fragments which were most likely the artisans' tools. Similar finds were uncovered in the T III/2 workshop, although in much lower quantities.

With regard to basic form and size, the crucibles are quite heterogeneous: small hemispherical (H. and mouth Dia. 5 cm) and bigger bowl-shaped examples (H. 5-9 cm, mouth Dia. 7-14 cm) occur as well, nevertheless, always with flat bottoms. Usually, a heavily vitrified outer layer<sup>22</sup> with molten metal pieces was still preserved (fig. 2). Hence their maximal volume is calculated to be between 33 and 323 cm<sup>3</sup>, which allows for melting or recycling; e.g. there was a maximum of approximately 295-2947 g of copper in the given crucibles. This amount of metal is suitable for casting either single objects or a series. The preliminary results of the SEM analyses executed on some metal samples taken from the crucibles<sup>23</sup> show that predominantly copper alloys were used

in both workshops, although a small crucible fragment from R 46 uniquely preserves molten gold globules on the interior surface. On the same fragment, characteristic traces (i.e. thin grooves) were revealed by microscopic analysis, deriving probably from the attempt of the metalworkers to remove the gold pieces adhering to the inner wall of the crucible after the metalworking process.

The range of products can be outlined on the basis of the casting moulds; all are made of fine tempered clay for the purpose of lost wax casting. Preserved imprints show that simple rings, wire jewellery (bracelets?) with ribbed decoration, buckles<sup>24</sup> and parts of statues (fig. 3.1) were manufactured here. A one-piece casting mould preserved intact from R 46 deserves particular attention (fig. 3.2). With computer tomography we were able to gain an insight into the object<sup>25</sup>. The CT-scans revealed that this mould was used to prepare pairs of studs with a circular flat plate. At the current stage of research, we can only suggest that similar studs, sometimes decorated with enamel<sup>26</sup>, were in use for fixing the (leather) straps of military equipment, such as belts<sup>27</sup> and armour<sup>28</sup>, known since the 3<sup>rd</sup> century. Not far from the workshop in front of taberna IV, a very similar stud with enamel decora-

21 A great amount of related material was found in the western and southern neighbouring structures of R 46, which in consequence is mentioned in the excavation diaries as room 46b.

22 Such an outer layer of rough-textured clay is usually added in order to ensure better overall refractory properties for the crucible and to prevent any metal loss in the case of a breakage caused by high temperature (Bayley/Rehren, Crucibles 50). For further details on the widespread use of this feature (called »Lutum«) from the Roman period onwards, see Furger, Schmelztiiegel 40-48.

23 See n. 2.

24 Several casting moulds of belt buckles bear strong resemblance to the late Antique B-shaped (Lyne, Belt Fittings 103, 105, 107 fig. 3-4. – Cf. Simpson, Belt-Buckles 193f.), kidney-shaped (Schulze-Dörrlamm, Schnallen 1, 51f.) and oval buckles (Schulze-Dörrlamm, Schnallen 1, 54-63).

25 Our special thanks are due to S. Ladstätter (director of the ÖAI-ÖAW and excavations in Ephesus), C. Topal (director of the Ephesus Museum in Selçuk), E. Korkmaz (commissar of the Ephesus excavations in the summer of 2015) and the local hospital in Selçuk for making the analyses possible.

26 See the 3<sup>rd</sup> c. hoard find from Wange consisting of numerous studs with a circular flat plate and specific coated and enamelled decoration (Lodewijckx et al., Roman Hoard 67, 74-78, 90-93 fig. 5-6).

27 Bishop/Coulston, Military Equipment 182f. fig. 118, 9-12. – Appels/Laycock, Military Fittings 92 fig. AA10, 14-16.

28 Appels/Laycock, Military Fittings 59f. fig. AA5.38.



**Fig. 3** Ephesus, north front area of Terraced House 2: **1** Fragment of casting mould for preparing part of bronze statue (negative imprint of the garment's folds) from workshop in R 46. – **2** Preserved one-piece casting mould for preparing pairs of studs with CT-scan on right. – **3** Enamelled stud from so-called Nymphaeum, in front of taberna IV. – (Photo ÖAW-ÖAI, N. Gail).

tion was found (H. 0.8cm, Dia. 2.3cm, **fig. 3.3**). Although it is tempting to suggest that the object represents a finished product of the workshop offered for sale in taberna IV, further research is needed to prove the current hypothetical connection.

The last group of finds, copper-alloy objects, includes a huge amount of the usual partly-processed waste material of metal workshops (e. g. wasters, cut and bent stripes and wires) and other objects (e. g. rings and buckles) which might be interpreted as semi-finished products.

In addition, over 50 bronze statue fragments (e. g. drapery folds and various body parts, such as fingers, a phallus, feet and toes) are known from the workshops and adjacent rooms located in the area of living quarter 7 and the tabernae<sup>29</sup>. The smaller fragments of approximately 5 cm × 6 cm (weighing 6-30 g) are concentrated mainly in R 46, whereas bigger fragments of approximately 9 cm × 9 cm (weighing 50-250 g) were found in the adjacent rooms. This might suggest that bronze statues had been dismantled and cut into smaller pieces in several steps before they were re-melted in the workshops. Hence these secondarily-acquired metal resources could be used not only to produce jewellery and dress accessories or other items, but also to repair older bronze statues or even

create new ones. The latter assumption is supported by the presence of mould fragments for casting parts of bronze statues<sup>30</sup>.

In summary, two places of production can be identified in the TH 2. As for the chronology, at present we have to rely on the analogies of archaeological finds from R 46 and T III/2 which presuppose a dating not earlier than the 5<sup>th</sup> century<sup>31</sup>. The question of whether metalworking activity in these rooms was contemporaneous or there was a chronological difference, shall remain open until the completion of the project. The wide range of products (from clothing accessories and jewellery to parts of statues) and the use of precious metals besides copper alloys indicates that local customers, as well as those in the wider vicinity of Ephesus, were supplied by the workshop(s) with products of different quality.

The other area that is a focus of our interest is located on the other side of the Embolos, east of the TH 2. Extensive renovation and remodelling measures were undertaken along this main street around the end of the 4<sup>th</sup> or the beginning of the 5<sup>th</sup> century. Several buildings, such as the Library of Celsus and the Heroon of Androklos, were adapted to serve as a decorative background to the newly-installed fountains and the street was also upgraded with statues, decrees and

29 Based on the statue fragments discovered in living quarter 6, previous studies have hinted at the recycling of bronze statues in Late Antiquity in the TH 2 (Rathmayr, *Skulpturenfunde* 2, 381 f.). Nevertheless, recycling older statues was not an uncommon practice even before Late Antiquity (Mirschenz, *Bronzestatuen* 150), as inscriptions from Ephesus also attest (lvE Ia no. 25, cf. Knibbe/Iplikçioğlu, *Inschriften* IX, 109 f. Inv. 4155).

30 An inscription from Ephesus dated to the 5<sup>th</sup> c. refers to the renovation and re-erection of a bronze statue (Knibbe/Engelmann/Iplikçioğlu, *Inschriften* XII 146 f. no. 74). Additionally, numerous statue fragments were found in the Great Theater of Ephesus during the excavations between 1993 and 2009. Some of these fragments preserved the undetached sprues and vents, clearly suggesting that bronze statues were probably recycled, cast and/or repaired

there as well (Aurenhammer, *Skulpturen im Theater* 368-370, especially n. 203-206). We express our special gratitude to M. Aurenhammer, who drew our attention to the finds and granted access to the material, which was under evaluation by her at the time.

31 Some examples can be mentioned: A rectangular buckle dated to the mid-5<sup>th</sup> c. (type B1 according to Schulze-Dörrlamm, *Schnallen* 1, 36 f. 41 fig. 16) was found in workshop R 46 together with a crucible and bronze statue fragments. In an adjoining room, a buckle with D-shaped loop and rounded or semi-circular plate, dating to the second quarter of the 5<sup>th</sup> c. (type A7 according to Schulze-Dörrlamm, *Schnallen* 1, 16. – Cf. Group II according to Simpson, *Belt-Buckles* 195 f. fig. 2) was discovered with slags and bronze statue fragments. For more about the problematic of dating, see n. 19.



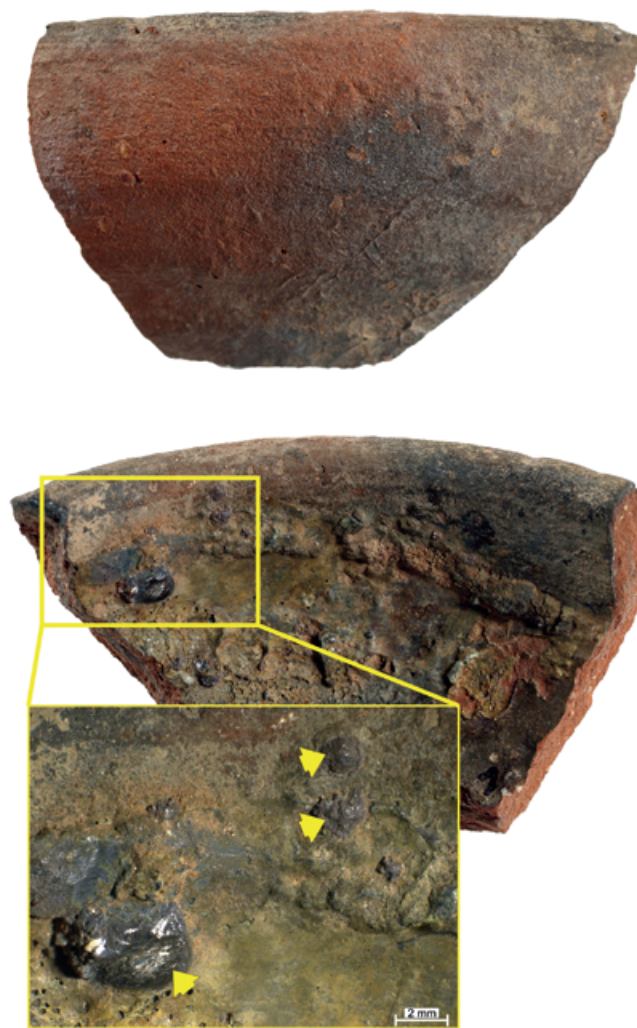
honorary inscriptions<sup>32</sup>. Subsequent to these renovations, the social and economic importance of the area must have increased significantly; therefore, the district attracted artisans of different crafts. Behind the colonnaded street a row of tabernae functioned as shops, taverns and workshops<sup>33</sup>.

The entrances of twelve tabernae situated between the Nymphaeum Traiani and the Hercules Gate were excavated in 2005<sup>34</sup>. An almost fully-preserved crucible (H. 10 cm, mouth Dia. 12.2 cm) and several smaller fragments of crucibles were found in excavations at entrances 2, 5 and 8<sup>35</sup>. The find context, stratigraphy and the chronology of the found ceramics date them to the late 5<sup>th</sup> or 6<sup>th</sup> century<sup>36</sup>. In connection with the Byzantine shops in Sardis, a similar case can be observed: crucible fragments and/or slags were found inside or directly in front of the shops W 7, E 5, E 10-11 and E 16<sup>37</sup>; nevertheless, no other evidence suggested that metal was cast there. However, this example shows that the crucibles found at the entrances of the shops in Ephesus are not unique cases.

A much greater number of crucible fragments came to light in 2005 in the northern neighbourhood of the tabernae at the Nymphaeum Traiani behind the north-eastern rear wall of its façade. Although the prime objective of the archaeological fieldwork was to learn more about the water supply network of the fountain, much information was gained about the use of its immediate surroundings as well<sup>38</sup>. Various, often correlated features (e.g. waste pits with mixed material of probably relocated workshop debris and a pit for lime slaking) were excavated which belong to the Late Antique / Early Byzantine phase of the area<sup>39</sup>. Around 80 fragments of crucibles (fig. 4), slags and some poorly-preserved casting moulds were found in several layers, which can be dated to between the second half of the 4<sup>th</sup> century and the 7<sup>th</sup> century.

Due to the presence of finds indicating metalworking from excavation sites (irrespective of their dating), one might suggest that in one or more of the tabernae<sup>40</sup> or in their direct vicinity, the workshops of metalsmiths (copper- or silversmiths?) offered their products directly to customers or supplied retail shops which were engaged only in sales.

From the frequently cited treatise of Julian of Ascalon of the 6<sup>th</sup> century<sup>41</sup>, it is known that the location of particular workshops was strictly regulated<sup>42</sup>, especially those which might cause a hazard due to sparks, smoke, noxious vapours or vibrations affecting the neighbouring buildings<sup>43</sup>.



**Fig. 4** Ephesus, area behind the Nymphaeum Traiani: crucible fragment with molten silver globes marked with arrows on the microphotograph. – (Photos NÖAW-ÖAI, N. Gail, Microphotograph D. Zs. Schwarcz).

The regulations listed in the treatise of Julian slowly became a requisite and customary part of Byzantine building and city planning all over the empire<sup>44</sup>. However, they could not have been applied in previous centuries, as the evidence from the presented archaeological sites has shown. Nevertheless, commercial factors must have played the most important role in establishing workshops in specific areas within or outside the city walls<sup>45</sup>.

32 Pülz, Stadtbild 544-548. 552.

33 Ladstätter, Ephesos 499.

34 Iro/Schweiger/Waldner, Kuretenstraße 54-65.

35 Iro/Schweiger/Waldner, Kuretenstraße 61 f. 78 fig. 20, 7.

36 Iro/Schweiger/Waldner, Kuretenstraße 61-64.

37 Crawford, Sardis 31-33. 56. 73f. 95 figs 249. 370f. 376.

38 Quatember et al., Nymphaeum Traiani 265. 267.

39 Quatember et al., Nymphaeum Traiani 267-289.

40 Crawford took the depiction on the gravestone of L. C. Atimetus (discovered in Rome) to illustrate a possible multi-functionality of shops with more than one room. One of the reliefs shows the production of an implement whereas on the other relief, a retail shop is depicted. Accordingly, the interpretation posits that the two reliefs represented different functions of rooms within the same shop (Crawford, Sardis 74).

41 For further details see Hakim, Julian 7 f.

42 Hakim, Julian 10. 12.

43 In this respect, glassmakers, glassblowers and blacksmiths were strictly prohibited from operating within towns because of the increased danger of fire (Hakim, Julian 10).

44 Hakim, Julian 6-10.

45 For details of the advantages for craftsmen of interrelated trades establishing clusters within the city, see: Holleran, Retail Trade 58-61. – With regard to concentration of specialized crafts in specific areas of different cities mentioned in written sources: in Rome, Ephesus, etc., summarized in Drexhage/Konen/Ruffing, Römische Wirtschaft 103 f. – In Constantinople, see n. 47. – In Thessaloniki, see Antonaras, Thessaloniki 25. 44.

Finally, preliminary results of the recent SEM analyses should be briefly mentioned. Several metal samples were taken from different crucible fragments found in the two metal workshops of TH 2, at both sites north of the Embolos (Nymphaeum Traiani and tabernae), and at the Magnesian Gate outside the city walls. On receiving the first results, an obvious tendency was spotted. Most of the samples from the metal workshops in TH 2 and at the Magnesian Gate can be identified as copper or copper-alloys<sup>46</sup>, whereas the ones from the other two sites (with very few exceptions) are silver or silver-alloys, which could mean that usage of the two main alloy types was favoured in different parts of the city.

Here we should recall the commercial map of Late Antique Constantinople. According to various literary sources, certain trades were concentrated in specific parts of the city, hence the silversmiths operated on the Mese and the coppersmiths to the north of the Law Basilica next to the Augustaion<sup>47</sup>. A similar concentration of certain trades can be assumed also in Ephesus. However, this assumption shall remain a hypothesis until the final evaluation of the project is completed, including more exact absolute and relative dating of archaeological features, interpretation of the find complexes, and eventually, the (technological) connections between the metalworking areas.

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46 Except the single crucible fragment with the molten metal globes, described above.

47 Mundell Mango, Commercial Map 194. 197. 207. – Cf. n. 45.

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## Zusammenfassung / Summary / Özet

### Von der Produktion zum Vertrieb. Nichteisenmetallbearbeitung im spätantiken und frühbyzantinischen Ephesus

Die Buntmetallverarbeitung in der frühbyzantinischen Zeit wird auf Grund der archäologischen Quellen aus den älteren als auch den jüngeren Grabungen in Ephesos untersucht. Den Schwerpunkt bildet dabei das Fundmaterial der metallverarbeitenden Produktionsstätten im Hanghaus 2, das Gusstiegel, Gussformen und Objekte aus Kupferlegierungen umfasst. Verschiedene naturwissenschaftliche Analysemethoden wurden angewandt, um Fragen bezüglich der Werkstattorganisation, des Materialverbrauchs bzw. des Recyclings zu beantworten.

### Üretimden Satışa. Geç Antik ve Erken Bizans Ephesus'unda Demir İçermeyen Metal İşçiliği

Erken Bizans dönemi demir içermeyen metal işleme uygulamaları, Ephesus'ta eski ve son zamanlardaki kazı çalışmalarından elde edilen arkeolojik verilere dayanarak incelenmiştir. Araştırmanın ana odak noktası, Teras Ev 2'deki metal atölyelerindeki kröze, döküm kabı ve bakır alaşımlı objeleri kapsayan en önemli buluntulardan oluşmaktadır. Metal kaynakların kullanımının ve geri dönüşümünün yanı sıra atölye düzenlemesi hakkında daha iyi bir anlayış elde etmek için farklı bilimsel analiz metotları uygulanmıştır.

### From Production to Sales. Non-Ferrous Metalworking in Late Antique and Early Byzantine Ephesus

Early Byzantine non-ferrous metalworking practices are studied based on archaeological data gathered from older and recent excavations in Ephesus. The main focus lies on the find material encompassing crucibles, casting moulds and copper-alloy objects from the metal workshops in Terrace House 2. Different scientific analysis methods were applied to gain a better understanding of workshop organization as well as the utilization and recycling of metal resources.