METAL PRODUCTION IN MEZRAA HÖYÜK IN THE EARLY BRONZE AGE

Derya YALÇIKLI*

Keywords: *Mezraa Höyük • Early Bronze Age • Euphrates • Metal Production • Crucible • Mould.*

Abstract: Metal objects and findings that suggest metallurgy activities were discovered in the Early Bronze Age architectural layers of Mezraa Höyük in the Birecik region. Among the finds were two crucible fragments and a casting mould. Analysis of the metal fragments preserved on the crucible parts revealed the presence of arsenical copper. Pins in well-known forms in the Middle Euphrates Region during the Early Bronze Age make another group of findings. According to the analysis, one pin was produced by arsenical copper alloy and the other one by tin-copper alloy. This data proves the existence of metallurgical activities in the second half of the Early Bronze Age, and the production of arsenical copper alloy.

ERKEN TUNÇ ÇAĞI'NDA MEZRAA HÖYÜK'TE METAL ÜRETİMİ

***Anahtar* Kelimeler:** Mezraa Höyük • Erken Tunç Çağı • Fırat Nehri • Metal Üretimi • Pota • Kalıp.

Özet: Şanlıurfa ili, Birecik ilçesinde bulunan Mezraa Höyük, Fırat Nehri'nin doğu kenarında yer almaktadır. Mezraa Höyük'ün en uzun yerleşim sürecini Erken Tunç Çağı temsil etmektedir. Bu sürece ait ele geçen bir grup buluntu merkezde madencilik faaliyetlerinin yapıldığını kanıtlamaktadır. Söz konusu buluntular arasında iki adet potaya ait parçalar ve bir adet döküm kalıbı yer alır. Erken Tunç Çağı'nın ilk yarısına tarihlenen pota parçalarının üzerinde korunan metal parçalarının analizinde arsen-bakır alaşımının varlığı saptanmıştır. Kalıp sayesinde de Erken Tunç Çağı ikinci yarısında madencilik faaliyetlerinin devam ettiği anlaşılmaktadır. Mezraa'da diğer bir buluntu grubunu ise bölgede Erken Tunç Çağı'nda tanınan formlara sahip iğnelerden oluşan ürünler oluşturur. İğnelerden bir tanesinin analizinde arsen-bakır, diğerinin ise kalay-bakır alaşımı olduğu saptanmıştır. Bu veriler, Mezraa'da Erken Tunç Çağı'nın ilk yarısında arsen-bakır alaşımından üretiminin yapıldığını ve bunun yanı sıra Erken Tunç Çağı'nın ikinci yarısında ise kalay-bakır alaşımından üretilmiş nesnelerin kullanıldığını göstermektedir. Kısıtlı alanlarda sürdürdüğümüz çalışmalardan elde ettiğimiz bu veriler, Mezraa'nın Erken Tunç Çağı boyunca ihtiyaçlarını karşılayacak boyutta bir metalürji teknolojisine ve üretim yapabilecek ekonomik güce sahip olduğunu kanıtlamaktadır.

---

* Assoc. *Prof. Dr. Derya Yalçıklı, Department of Archaeology, Çanakkale Onsekiz Mart University, Terzioğlu, Çanakkale/ Türkiye, dyalcikli@comu.edu.tr, deryalcikli@gmail.com; ORCID ID: 0000-0003-4998-7072*
Geliş Tarihi: 21.12.2021; Kabul Tarihi: 06.05.2022; DOI: 10.36891/anatolia.1039487
This study was written during the pandemic, and I would like to thank Prof. Dr. Ekin Kozal, who gave me invaluable assistance in acquiring hard to obtain publications. I would also like to extend sincere thanks to faculty member Dr. Ümit Güder who analysed the examples, to Prof. Dr. Tuba Ökse, Hülya Yalçıklı, and research assistant Fatih Yılmaz. Thanks also go to my master's degree student Yunus Kaptan who lent assistance during the study.

Introduction

Mezraa Höyük in the Birecik district of the Şanlıurfa province, Turkey, is located on the eastern bank of the Euphrates River (Fig. 1). Excavations were conducted across three separate areas: the east slope, the southeast slope, and the northeast sector between 2000 and 2007. The Early Bronze Age architectural levels, which were covered by layers of Middle Bronze Age, Iron Age, and Middle Age, represent the largest and longest period of Mezraa Höyük. The architecture and the small findings recovered from the building layers that represent this period give detailed insight to the Early Bronze Age in the northern part of the Middle Euphrates Region. A remarkable group of findings among these consist of metal artefacts and the evidence of metal production.

Crucibles and Moulds

The findings indicating metallurgical activities carried out in Mezraa Höyük were found in the building levels dating back to the Early Bronze Age. Among these findings, there are two crucible fragments and a casting mould. The findings were recovered from different levels of the building and different locations; so, these were not found in a workshop context. The first crucible fragment (Fig. 2.1, 4.1) was found on the stone floor, named T125, of the structure unearthed in Level IV in Trench P/15 on the southeast slope, dating back to the Early Bronze Age I[1]. No other items related to metallurgy were found in the structure. The baked clay crucible fragment is formed as a round based bowl. The deformation of the porous structure on the inner and outer surfaces of the crucible reflects exposure to high temperatures. Small metal residues adhering to the pouring lip of the crucible fragment were preserved.

Fragments of the second crucible (Fig. 2.2, 4.2) were found on the floor, named A1029, of a structure located at the southern part of Trench R/15 on the South-eastern Slope. Due to intense corrosion, only a small part of this floor was preserved and the pottery fragments belonging to the Early Bronze Age II were found on this layer and in its immediate vicinity[2]. Many large and small fragments of a baked clay crucible were found, and its pouring lip was partially restored. The crucible had a trough-like spout; however, the shape of the bowl could not be determined According to the section of the connection of the pouring lip, the bowl seems to have a rounded base. The interior of the pouring lip shows a porous deformation due to high temperatures.

Small metal residues are preserved on the inner surface of the fragments of the crucible (Fig. 2.2). Similar examples of bowl-shaped crucibles with pouring lips and round-bases are found in the Late Chalcolithic levels at Tepecik[3] and Tülintepe[4] in the Upper Euphrates Region, and Kuruçay in the Lakes

[1] Finkbeiner et al. 2015, 432-433: EME 2.
[2] Finkbeiner et al. 2015, 432-434: EME 2-3.
[3] Müller-Karpe 1994, Pl. 8.4.
[4] Müller-Karpe 1994, Pl. 9.8.

Region[5]. Similar crucibles can also be dated back to the Early Bronze Age in Troia[6] in Western Anatolia, and İkiztepe[7] in Northern Anatolia. Similar simple-shaped crucibles are also found in Arslantepe dating back to the Early Bronze Age III[8], and this crucible type was still in use during the Middle Bronze Age in Central Anatolia[9]. Whether both bowls had handles in the form of pan or ledge handles is not known.

The mould from Mezraa Höyük (Fig. 3, 5) was recovered from the mixed debris from Trench S 12 on the East Slope, also containing other pottery fragments from architectural layers dated to the Early Bronze Age III[10] which were destroyed in the medieval (11-13. centuries)[11] period.

It would be appropriate to date the mould back to the second half of the Early Bronze Age, considering the ceramic fragments obtained from the context. The baked clay mould is broken, and considering the preserved part, it was formed as a square prism. The preserved length of the mould was 10.2 cm with a width of 6.85 cm and a thickness of 6.62 cm. On four wide lateral faces of the prism, negative spaces for items to be produced had been shaped. The square-shaped base is flat. One of the faces bear the casting of a flat axe, possibly a chisel or rod-shaped ingot on the second face, a flat axe on the third face, and a dagger on the fourth face. If the items to be produced using the casting technique had simple and massive shapes. This mould, which might have been among the preferred one-piece moulds, was used by pouring smelted metal into a cavity that had the shape of the product. can be assumed that the mould was used many times, since the colour changes indicate that it was exposed to high temperatures. One of the most important features of the mould was a round bore (Fig. 5. section B) located on the rear end of the flat axe on the first face. This bore was opened to easily create a hole that would be formed as a result of the removal or breaking off a cylindrical clay core of the same diameter placed vertically in it after casting. Accordingly, these holes were placed in the rear side of a part of the flat axe[12] in order to facilitate the attachment of the axe head to the shaft that were created during casting.

In the Middle and Upper Euphrates regions, the number of sites with strong evidence of Early Bronze Age metal production has gradually started to increase, and a considerable number of furnaces, crucibles, moulds, and similar items used in metal production have been uncovered. A one-piece mould at Hacınebi Tepe[13], a crucible and a mould in Arslantepe[14], a smelting furnace, a one-piece mould and a copper slag in

[5] Duru 1996, 52 Fig. 146/7, 149/6, 147/1, 149/7.
[6] Blegen et al. 1951, 34, 53-54 Pl. 80.33.1263-1265.
[7] Müller-Karpe 1994, Pl. 10.2.
[8] Di Nocera 2013, Fig. 15.2.
[9] Özgüç 1955, 74.
[10] Finkbeiner et al. 2015, 436-438: EME 4-5.
[11] Yalçıklı – Tekinalp 2002, 172 Fig. 10d.
[12] Woolley 1914, Pl. XXIV; Bittel 1940, Fig. 13 Pl. V. S3448, S3446.
[13] Stein 1997, 101.
[14] Di Nocera 2013, 115, 121 Fig. 3.12-13, 5.14-15; Frangipane 2017, Fig. 15.1a, c.

Norşuntepe[15], a slag in Fatmalı-Kalecik[16], a furnace, a crucible, a slag in Değirmentepe[17], a slag in Tülintepe, Tepecik[18], and the mould in Pulur-Sakyol[19] can be considered as examples from the Chalcolithic period.

In the Early Bronze Age, an increase in the number of settlements where metal production activities were carried out in the Middle and Upper Euphrates regions was observed. Among the findings dating back to the beginning of the Early Bronze Age, the presence of workshops in Tell Chuera[20], Tell Bderi[21], and Arslantepe[22] draws attention. The following may be considered evidence of production of metal in addition to the workshops: an axe mould in Halawa[23]; a one-piece axe mould in Chagar Bazar[24]; a crucible fragment preserved in the pouring lip in Tell Shioukh Fawqani[25]; crucibles in Zeytinli Bahçe Höyük[26]; a slag in Tilbes Höyük[27]; a slag in Lidar Höyük[28]; a mould in Hassek Höyük[29]; a mould in Tepecik[30]; and a crucible, a mould, and slags in Norşuntepe[31]. Among the centres with metal workshops dating to the latter part of the Early Bronze Age take place Jerablus Tahtani[32], Habuba Kabira[33], Chagar Bazar[34], Tell Brak[35], Tell Qara Quzaq[36], and Arslantepe[37]. An important group of metal producing tools belonging to this period are moulds[38] in Tell Ahmar[39], a one-piece mould and an ingot or chisel mould in Tell Beydar[40], the mould of the lead figure in Titriş Höyük[41], and a two-piece mould in Norşuntepe[42]. These moulds appear as findings representing different technological developments. While examples with a single or a few castings on one face were common among mould shapes, also multiple moulds with multi-faced castings appear, of which four lateral faces, as well as rare top and bottom base faces were used. The mould from Mezraa Höyük is a multiple-faced mould type. Similar moulds are found in many sites; an early example is the Pulur-Sakyol mould dating back to the Late Chalcolithic Age[43]. Similar moulds are

15 Hauptmann 1982, 31; Schmidt 2002, 40, 549-550, 41.547.
16 Hess et al. 1998, 59.
17 Kunç et al. 1983; Esin 1986, 145.
18 Özbal 1983, 210; Esin 1987.
19 Koşay 1976, 33, 72, 193, Pl. 110.425.
20 Pfälzner 2001, 342 Pl. 63.
21 Pfälzner 2001, 286.
22 Di Nocera 2013, 124 Fig. 9.
23 Orthmann 1989, 107 Fig. 70.
24 Mallowan 1937, 153 Pl. XVIII.B.
25 Bonacossi 2005, 63 Pl. 52.
26 Palmieri – Di Nocera 2004, 377.
27 Gil et al. 2000, 27.
28 Hauptmann 1985, 205.
29 Behm-Blancke 2003, 483.
30 Esin 1982, 92, 65.7, 78.16 T74-145.
31 Hauptmann 1982, 21; Schmidt 2002, 40 Pl. 41.549.
32 Peltenburg – Wilkinson 2008, 28, 30.
33 Stromenger 1980, 78-79 Fig. 81.
34 Mallowan 1937, 158 Pl. XVIII.B; 1947, 160 Pl. XXIXA.
35 Oates et al. 2001, 247-248 Fig. 268.
36 Montero Fenollos 1999, 452 Fig. 1.
37 Di Nocera 2013, 133 Fig. 15.1, 2; Frangipane 2017, 172 Fig. 15.1d.
38 M. Fenollos (1999, 451-452) suggests the late stage of the Early Bronze Age for the dating of the moulds unearthed under the Aramaic structure.
39 Thureau-Dangin – Dunand 1936, 87 Fig. 26.
40 van der Stede 2005, 36 Fig. 183.
41 Matney et al. 1997, 68-69 Fig. 19-20.
42 Hauptmann 1979, Fig. 32.4; Schmidt 2002, 40 Pl. 41.552.
43 Koşay 1976, 33, 72, 193, Pl. 110.425.

known from the Early Bronze Age settlements at Tell Brak[44], Tell Tayinat[45], and Arslantepe[46]. It is also evident that this type of mould was used extensively around second millennium BC[47].

Toggle-Pins

The second artefact group consist of metal pins. Three of the four toggle pins dating back to different stages of the Early Bronze Age were found in settlement layers, and one was found on the surface. Considering their shape, these toggle pins on three different types. The first type is characterized by a toggle pins with a body with grooves and a conical head, found in the structure located in Trench P 14 of the southeast slope, dating back to Early Bronze Age II[48] (Fig. 2.3a, 4.3a).

The current length of the toggle pin bent in a "U" shape was 3.43 cm, the actual length is calculated as 6.8 cm, and body diameter is 0.3 cm. The head of the toggle pin had a small pyramidal structure, and the join of the head to the body is decorated with four evenly spaced horizontal grooves. The pin body has a rounded cross section and a tapering shape.

There are two toggle pin of the second type with a conical head and a needle's eye (Fig. 2.3b, c, 4.3b, c). One of these was obtained from a context destroyed by the Middle Ages on architectural levels dating back to the Early Bronze Age III[49] in Trench S/13 on the east slope (Fig. 2.3b, 4.3b) and can be dated to the late phase of the Early Bronze Age, according to pottery assembalges. The toggle pin with a pyramidal head is 8.3 cm long and 0.7 cm in diameter. The needle's eye on the body with circular cross section, tapers towards the end.

The second toggle pin was found broken on the surface of the southeast slope. According to its shape, the toggle pin can be dated back to the Early Bronze Age (Fig. 2.3c, 4.3c). The preserved part is 7.2 cm long. The toggle pin with a body with 0.6 cm in diameter, has a conical shaped headand a needle's eye.

The toggle pin of the third type is shaped by a bend looped head with a needle's eye and spherical head. The toggle-pin is found in Trench M/12 of the northeast section on the summit in connection with structures dating back to the Early Bronze Age III/IVA[50] (Fig. 2.3d and 4.3d). Some parts of its body was broken, and the survived part is 5.1 cm long. The toggle pin had a curved body and a spherical head, 0.8 cm in diameter. The body with a needle's eye is 0.4 cm in diameter.

In the Middle and Upper Euphrates regions, ornamental metal toggle-pins are dated to the Chalcolithic Age. A toggle-pin of this type without a a needle's eye and with simple decoration is found in the Uruk-period contexts of Tell Sheikh

[44] McDonald et al. 2001, 247-248 Fig. 267-269.
[45] Braidwood – Braidwood 1960, 450-451 Fig. 350.1, Pl. 49.5.
[46] Di Nocera 2013, Fig. 15.2.
[47] Müller-Karpe 1994, 200-205 Pl. 22-36.
[48] Finkbeiner et al. 2015, 432-434: EME 2-3.
[49] Finkbeiner et al. 2015, 434-436: EME 4.
[50] Finkbeiner et al. 2015, 434-437: EME 4-5.

Hassan[51], and another one with a needle's eye and conical head in Tepe Gawra[52].

An early example of toggle-pins with conical head and grooves (Fig. 2.3a, 4.3a) is found in Zeytinli Bahçe Höyük[53], located close to Mezraa Höyük, dating back to the Late Uruk Period. Similar toggle-pins are also known from Hacınebi Tepe[54], Birecik Cemetery[55], Carchemish[56], Hassek Höyük[57], Arslantepe[58], Samsat[59], Norşuntepe[60], and Taşkun Mevkii[61], dating to the Early Bronze Age.

Similar conical headed toggle-pins with conical toggles and needle's eyes are found (Fig. 2.3b, c, 4.3b, c) in Birecik Cemetery[62] and Carchemish[63] in contexts dating to the first half of the Early Bronze Age, and in Tell Brak[64], Halawa[65], Qatna[66], Wreide[67], Tell Qara Quzaq[68], Dibecik Tombs[69], Gedikli-Karahöyük[70], Oylum Höyük[71], and Titriş Höyük[72] in context dating to the the second half of the Early Bronze Age.

Toggle-pins with bent spherical toggles and needle's eyes (Fig. 2.3d, 4.3d) were found in Halawa[73], Tell Chuera[74], Tell Banat[75], Tell es Sweyhat[76], Wreide[77], Umm el-Marra[78], Tawi[79], Ayyıldız and Dibecik tombs[80], Gre Virike[81], and Titriş Höyük[82] dating back to the middle and late phases of the Early Bronze Age.

H.G. Egeli[83], F.F. Squadrone[84] and L.A. Stork[85] conducted detailed studies on toggle pin dating back to the Early Bronze Age found in the Middle and Upper Euphrates regions. Squadrone[86] stated that, among the toggle pin found in the Carchemish region, conical-headed toggle pin was common in the early period and that this refers to the intensity of the relations between the Carchemish-

51 Boese 1995, 60 Fig. 11.d.
52 Rothman 2002, 64 Pl. 77.2730.
53 Frangipane et al. 2002, 44 Fig. 12.
54 Stein 1997, 130 Fig. 4.H.
55 Sertok – Ergeç 1999, 93 Fig. 9.D; Spuadrone 2007, Fig. 13.1.1-2; 2015, 312-313 Pl. 2.21, 22 Type B10.
56 Woolley 1954, Pl. 60.b, 61.b.
57 Bhem-Blancke 1984, 50 Fig. 8.4.
58 Palmieri 1981, 118 Fig. 10.5,6; Di Nocera 2013, Fig. 8.1-2.
59 Özgüç 2009, 80.
60 Hauptmann 1982, Fig. 26.6.
61 Sagona 1994, 9 Fig. 68.5, 9.
62 Spuadrone 2007, Fig. 13.4.2; 2015, 318 Pl. 2.17-20 Type A10.
63 Woolley 1921, 133,134 Pl. 27.a8.
64 McDonald et al. 2001, Fig. 257.54.
65 Orthmann 1981, 55-57 Pl. 68.100-111; Novak 1994, 240 Fig. 72.18.
66 Lamoni 2012, 352 Fig. 2.6-10, 4.
67 Orthmann – Rova 1991, Fig. 26.W66:32.
68 Montero Fenollos 1999, 454 Fig. 3.
69 Spuadrone 2007, Fig. 13.9.13.
70 Alkım – Alkım 1966, 17 Fig. 36.
71 Özgen et al. 1997, 60 Fig. 12.2.
72 Nishimura 2015, Fig. 5.l.
73 Orthmann 1981, 57 Pl. 71.10-11, 54-55, 63.40-48.
74 Moortgat 1965, 43, Fig. 30; Orthmann et al. 1995, 128 Fig. 73.73.
75 Porter 1995, 8, 21 Fig. 5; Porter – McClellan 1998, 33-34 Fig. 23.5-6.
76 Zettler 1997, 56 Fig. 3.20.
77 Orthmann – Rova 1991, Fig. 18.W54B:08, 26.W66: 34-39.
78 Schwartz et al. 2006, 607-608 Fig. 8.
79 Kampschulte – Orthmann 1984, Pl. 1.6-7, 16b.14.
80 Spuadrone 2007, Fig. 13.9.3,10-11; 2015, 319-320 Pl. 4.9-15 Type A17.
81 Ökse 2006, 24-25 Fig. 29.
82 Algaze et al. 1995, 28 Fig. 34.
83 Egeli 1995.
84 Spuadrone 2007; 2015.
85 Stork 2014, a, b; 2015.
86 Spuadrone 2007, 210.

Karababa regions and the Habur-Old Mosul-Dam regions. She considered spherical headed toggle pin, which make up a remarkable group, among the new types found in the middle of the Early Bronze Age. According to the study of Stork, on the distribution area of toggle pins[87], most of the toggle pin unearthed in the Middle Euphrates region were found in graves. Although the toggle pins obtained from Mezraa Höyük are few in number, their presence in the habitation levels and the existence of examples of different types indicate that toggle pins were widely used in daily life apart from tombs.

Analyses

The crucible fragments and preserved metal residues on crucibles and toggle pins were provide evidence of metal production in Mezraa Höyük. X-ray fluorescence (XRF) spectroscopy analyses were performed on preserved metal residues in one fragment of one of the crucibles and on two different fragments of another crucible (Table 1).

According to the analysis, 95.15%, 88.34%, and 78.45% copper oxide and 3.265%, 2.585%, and 1.80% arsenic trioxide have been observed on the first mentioned crucible (Fig. 2.1). One of the fragments of the second crucible (Fig. 2.2) includes 57.93%, 52.765%, and 50.85% copper oxide and 1.05%, 0.485%, and 0.43% arsenic trioxide. Tin is observed in none of these fragments.

Two toggle-pins (Fig. 2.3a, b, 4.3a, b) could not be analysed, since these are inventarized in the Museum. Only portable X-ray fluorescence (XRF) spectroscopy analysis was performed on two toggle pins (Fig. 2.3c, d, 4.3c, d) toggle pins (Table 1) The analysis on two toggle pins (Fig. 2.3c, 4.3c) revealed 93.8% copper and 2.25% arsenic indicating arsenical copper alloy. The other toggle-pin (Fig. 2.3d, 4.3d), includes 92.7% copper and 3.86% tin, indicating a copper-tin alloy. Unlike other analysed examples, this toggle pin was the only example with copper-tin alloy. Considering the low content of tin in its body, it is difficult to talk about the existence of bronze in the proper sense. The question is, whether the ratio of the alloy is sufficient for the hardness aimed for a qualified product.

The first toggle-pin had a shape characteristic for the early stage of the Early Bronze Age, and its alloy ratios are in harmony with the values obtained from the crucible fragments. The second pin found in a context dating to the Early Bronze Age III/IV proves the existence of tin-copper alloy products in this period. In Mezraa Höyük, no evidence indicating the presence of tin was found in the late phase of the Early Bronze Age. The existence of a casting mould at the mound indicates continuity of metallurgical activities in this period. There is an important point to be emphasized: Although the toggle-pin was found in Mezraa Höyük, it might have not been produced there. This type of toggle-pins are extensively used in this period; so, it is possible that this artefact might have been produced in another site and imported to Mezraa Höyük.

[87] Stork 2014b.

Arsenical Copper Metallurgy in Anatolia

Our knowledge about the development of Anatolian metallurgy comes mostly from the data obtained from the analysis of metal artefacts. In the studies conducted on metal findings dated to the Chalcolithic Age and Early Bronze Age I-II, a significant part of the technological development was the hardening of copper. According to the analyses, arsenic and tin used for hardening copper had different development paths in technological processes. In the Chalcolithic Age, the processes of copper smelting and copper hardening with arsenic has an almost parallel development. This technological development can be observed over a wide geography including Anatolia, Iran, Palestine, and Syria from the late sixth millennium BC to the early fourth millennium BC[88]. Among the arsenical copper-products, the finds from Palestine have an important place among the early examples[89]. A similar item from Habuba Kabira-South in Syria dates back to mid fourth millennium BC[90]. Hacınebi Tepe[91], Hassek Höyük[92], and Arslantepe[93] are among the settlements revealing items produced with arsenical copper during the Late Chalcolithic Age in the Middle and Upper Euphrates regions.

Arsenic was used in Tell Brak[94] and Chagar Bazar[95] in Syria during the Early Bronze Age. Arsenic was also present in the metal findings dating back to the Early Bronze Age I-II in Zeytinli Bahçe Höyük in the vicinity of Mezraa Höyük, and nickel was also found in this alloy. Arsenic and nickel were determined in slag fragments, probably occured during the production of copper in the Early Bronze Age I in the Tilbes Höyük Similar items are also found in the middle and late phases of the Early Bronze Age at titriş Höyük[96]. Moreover, Özbal and Turan[97], determined 3.74% of arsenic in a piece of metal dating to the end of the Early Bronze Age; suggested that arsenic was added intentionally[98].

As a result of the analysis of metal residues found in Mezraa Höyük crucibles, differenceshave been determined in the copper and arsenic ratios of three different examples. While this result may indicate smelting processes performed in different time periods, it may also suggest the presence of an alloy without homogeneous

88 Hauptmann 2007, 295-296; Neukirchen 2016, 33.
89 Shalev – Northover 1993; Tadmor et al. 1995, Tab. 2.
90 Montero – Fenollos 1999, 453.
91 Özbal et al. 1999, 43.
92 Behm-Blancke 1984.
93 Palmieri – Di Nocera 2000, 181; Di Nocera 2010, 256-257; Frangipane 2017, 193.
94 Moorey – Schweizer 1972, 186.
95 Moorey – Schweizer 1972, 187.
96 Palmieri – Di Nocera 2004.
97 Özbal – Turan 2002, 62.
98 Pernicka et al. (1990, 268) argue that the presence of arsenic in the copper alloy content of more than 2% indicates the existence of a deliberate alloy production. Although the determination of this ratio as a definite limit for differentiation is discussed by many scientists, this ratio is important because it represents the amount required for the hardening of copper. The mixture ratio, which is considered necessary to determine the differentiation of naturally arsenic-containing copper with the deliberate production of arsenical copper, is a topic that has long been discussed by scientists (Hauptmann 2020, 385-393).

distribution, since it was not mixed well. Tin was not used for hardening copper in the crucible examples. On the other hand, it is unclear whether the determined amount of arsenic was in the aimed ratio or whether a conscious hardening process was carried out, since the samples taken from the crucible fragments may indicate any phase of the preparation stage. Among the arsenic trioxide value above 1.8% taken from different residues of the first crucible, 3.2% is a remarkable value. Considering that the targeted amount of arsenic in copper to provide hardness is 2%, this amount is above the limit. The samples taken from the second crucible, the ratio of arsenic trioxide is around 1% and lower (except for one value); so, the analyses on samples taken from different parts indicated the existence of arsenic in the copper content of the crucible.

Nickel that was evidently found in a proportion of 1.35-2.79% on the second fragment of the second crucible and in smaller amounts in toggle-pins. The existence of nickel in one of the two samples taken from the crucible and its absence in the other sample suggests metal residues from different raw material sources or coating of the crucible in different processes.

Metal finds in the region including copper, arsenic, and nickel are dated to the Chalcolithic Age in Hassek Höyük[99] and Hacınebi Tepe[100]. To the north of the region, arsenic and nickel at slags from Arslantepe[101]. Palmieri and Di Nocera[102] suggested that the findings indicate interactions of Arslantepe with the aforementioned settlements. Palmieri and Di Nocera[103] stated that the metallurgical activities carried out in Zeytinli Bahçe Höyük were limited to the first half of third millennium BC; moreover, copper, arsenic, and nickel were found together in Zeytinli Bahçe Höyük and Titriş Höyük. Slag samples dating the Early Bronze Age I in Tilbes Höyük and were determined to have been used in the production of copper artefacts[104]. From late Chalcolithic/Early Bronze Age, metal artefacts containing copper, arsenic and nickel have been recovered in Tülintepe and Tepecik[105].

These samples contain copper, arsenic and nickel all in together. E. Pernicka[106] points out the ores containing Cu-Ni-As and focuses on this property as an indicator for determining the source of the raw material. Ü. Yalçın, G. Yalçın[107] and H. Hauptmann[108] indicated the Cu-Ni-As contents in these materials as characteristics linked to the ores with ophiolite. They suggested the sources of findings recovered in Anatolia might have brought from orpiolite ores either in Anatolia or Northern Iran. Yalçın and Yalçın assessed the previous researches on ophiolite ores in Eastern Anatolia, and drew the attention to some of the important ophiolite ores those discovered close to Tunceli-Ovacık, Pancarlı and Kakbil as well as the cedac-

[99] Schmitt-Strecker et al. 1992, 111.
[100] Özbal 1996, 109-110.
[101] Frangipane 2017, 193.
[102] Palmieri – Di Nocera 2000, 182.
[103] Palmieri – Di Nocera 2004, 377-379.
[104] Gil et al. 2000, 27; Özbal - Turan 2002, 63.
[105] Yalçın – Yalçın 2008, 106 Tab. 1; 2009, 128-132 Tab. 1,3.
[106] Pernica 1995.
[107] Yalçın – Yalçın 2008, 106, 120-121.
[108] Hauptmann 2007.

sulfate ores near Elazığ-Guleman, Palu and Haçan, and with small copper ores located between Malatya and Siirt. They also pointed out that these ores contain As-Ni, being the potential source of the copper used in the aforementioned sites[109]. The ore resources containing copper, arsenic, and nickel are spread over a wide area extending from Caucasus, and Iran to Palestine; so, it is difficult to determine the sources of raw materials used for production of metal findings discussed here[110].

The discovery of iron components in toggle-pins and crucibles appears as a significant outcome relating to ore sources. Hauptmann[111] who points out to the iron content in the ores of Cyprus as an indicator of copper mines with similar contents, obstructing the distinguishing of ores from each other. In their research on the Ergani ore deposits Özbal et al.[112] found nickel in the ore content along with copper at Hacınebi Tepe findings, indicating the probable raw material source of the Ergani deposits. This estimation may be valid for the Mezraa Höyük located near Hacınebi Tepe and other settlements in the region.

Conclusions

Evidence of metallurgical activities in the region, started in the Chalcolithic Age and increased by diversifying in the Early Bronze Age, revealed also technological developments. Ore, furnace, slag, crucible, and one-piece moulds among the archaeological findings have been obtained from the Chalcolithic settlements in the Middle and Upper Euphrates regions. Technological developments joined to the existing production system in the Early Bronze Age show that the metal production had been accelerated and diversified in a short time. The data reflects advanced technological knowledge. For example, one-piece moulds began to be used in the Chalcolithic Age and developed in accordance with the needs occurred in the first half of the Early Bronze Age, and complex types began to be used. Findings related to metallurgy, consisting of crucible fragments and moulds from Mezraa Höyük, indicate that the mound had an important place in the development of metallurgy. We are familiar with the pouring lips and similar examples of the small-volume bowls of the crucibles dating to the first half of the Early Bronze Age in the region. These findings have parallel features with the metallurgical activities carried out in the region. The products were obtained from different levels and contexts in Mezraa Höyük, indicating metallurgical activities carried out in the first half of the Early Bronze Age and the economic power and metal technology performed in the settlement. It is certain that the technology of arsenic-copper alloy in the first half of the Early Bronze Age continued until the middle of third

[109] See Yalçın – Yalçın 2008 for resources and more detailed information focusing on the researches on ophiolite included ore beds located in Eastern Anatolia.

[110] Frangipane 2017, 193; Hauptmann 2007, 297-301 Fig. 8.19-20; Yalçın – Yalçın 2008, 116 Fig. 17 for the distribution of similar raw material resources.

[111] Hauptmann 2007: 61.

[112] Özbal et al. 1999, 59, 61, 65 Tab. 1.

millennium BC. The tin-copper alloy is detected only at a toggle-pin with a spherical head, from the to the second half of third millennium BC. Similar toggle-pins were used extensively in the region during this period. Considering the toggle-pin, the use of tin-copper alloy is determined at this period; however, no data indicating that the pin was produced in the settlement could be obtained. Possibly, some of the needs were met by local producers and metal products as well as pottery might have been produced in certain workshops and distributed in the region as a commercial material. The mould indicates metal production at the site in the first half of third millennium BC and continued in the second half. This data is obtained from the studies we carried out in limited areas; on the other hand, this data shows that the settlement performed metallurgy that met the needs throughout the Early Bronze Age.

Catalog

Figure 2.1, 4.1. Crucibles, P/15, 0082V04, context: T125.
Baked clay, L 6,4 cm, W 3,6 cm, H 1,4 cm.
color: external: 2,5YR5/8-5YR5/1 gray, internal: 2,5YR6/1 reddish gray, core: 5YR5/1 gray
Figure 2.2, 4.2. Crucibles, R/15, 7034V11**,** context: A1029.
Baked clay, L 7,1 cm, W 5,5 cm, H 2 cm.
color: external: 10R5/4 weak red-10YR7/8 yellow, internal: 10R3/1 very dark gray, core: 10R3/1 very dark gray.
Figure 3, 5. Mold**,** S/12, 448V01.
Baked clay, L 10,24 cm, W 6,85, H 6,62 cm.
color: 10R4/6 red-10YR2/1 black.
Published: Yalçıklı – Tekinalp 2002: 172 Fig. 10d
Figure 2.3a, 4.3a. Pin, P/14, 5006V15, context: A802
L 3,43 cm dia. 0,3 cm, open state 6.8 cm
Figure 2.3b, 4.3b. Pin, S/13, 6012V04, context: A611
L 8,3 cm, dia. 0.7 cm.
Figure 2.3c, 4.3c. Pin, S/15, 5500V02, context: Surface
L 7,2 cm, top 1,9-1,5 cm, dia. 6 mm.
Figure 2.3d, 4.3d. Pin, M/12, 4550V01, context: A750
L 5,1 cm, top dia. 0,8 cm, body dia. 0,38 cm

List of Figures and Table

References

Algaze et al. 1994 — G. Algaze – P. Goldberg – D. Honca – T. Matney – A. Mısır – A. Rosen – D. Schlee – L. Somers, "Titris Höyük, A Small EBA Urban Center in Southeastern Anatolia: The 1994 Season", *Anatolica* 21, 1995, 13-64.

Alkım 1966 — U.B. Alkım – H. Alkım, "Gedikli *(Karahöyük)* Kazısı Birinci Ön-Rapor", *Belleten* XXX, 1966, 1-26.

Behm-Blancke 1984 — M.R. Behm-Blancke, "Hassek Höyük, Vorläufiger Bericht über die Ausgrabungen der Jahre 1981-1983", *IstMitt* 34, 1984, 31-149.

Behm-Blancke 2003 — M.R. Behm-Blancke, "Northern Frontiers: Early Ninevite 5 Contacts with Southeastern Anatolia", in: E. Rova – H. Weiss (eds.), *Subartu IX: The Origins of North Mesopotamian Civilization: Ninevite 5 Chronology, Economy, Society* (New Haven 2003) 481-492.

Bittel 1940 — K. Bittel, "Der Depotfund von Soloi-Pompeiopolis", *ZA* 46.1, 1940, 183-205.

Blegen 1951 — C.W. Blegen – J.L. Caskey – M. Rawson, *Troy: the Third, Fourth, and Fifth Settlements*, Vol. II. (London 1951).

Boese 1995 — J. Boese, *Ausgrabungen in Tell Sheikh Hassan, 1. Vorläufige Berichte über die Grabungskampagnen 1984-1990 und 1992-1994* (Saarbrücken 1995).

Bonacossi 2005 — D.M. Bonacossi, "The Late Chalcolithic and Early Bronze Age I Sequences of Area D", in: L. Bachelot –F.M. Fales (eds.), *Tell Shiukh Fawqani 1994-1998, History of the Ancient Near East/Monographs,* VI.1 (Padova 2005) 21-249.

Braidwood – Braidwood 1960 — R.J. Braidwood – L.S. Braidwood, *Excavations in the Plain of Antioch I. The Earlier Assemblages Phases A-J* (Chicago 1960).

Di Nocera 2010 — G.M. Di Nocera, "Metals and Metallurgy. Their Place in the Arslantepe Society Between the End of the 4th and Beginning of the 3rd Millennium BC", in: M. Frangipane (ed.), *Economic Centralisation in Formative States. The Archaeological Reconstruction of the Economic System in 4th Millennium Arslantepe* (Roma 2010) 255-330.

Di Nocera 2013 — G.M. Di Nocera, "Organization of Production and Social Role of Metallurgy in the Prehistoric Sequence of Arslantepe (Turkey)", *Origini* XXXV, 2013, 111-142.

Duru 1996 — R. Duru, *Kuruçay Höyük II. 1978-1988 Kazılarının Sonuçları Geç Kalkolitik ve İlk Tunç Çağı Yerleşmeleri* (Ankara 1996).

Egeli 1995 — G. Egeli, "The Metal Pins from Eastern and Southeastern Anatolia During the Third and the Beginning of the Second Millennia BC", in: İstanbul Üniversitesi, Prehistorya Anabilim Dalı (ed.), *Halet*

Çambel için Prehistorya Yazıları/ Readings in Prehistory Studies Presented to Halet Çambel (İstanbul 1995) 175-216.

Esin 1982 — U. Esin, "Tepecik Kazısı, 1974", *Keban Projesi 1974-1975 Çalışmalar / Keban Project 1973 Activities* (Ankara 1982) 71-93.

Esin 1986 — U. Esin, "Değirmentepe (Malatya) Kazıları Arkeometrik Araştırmalarına Toplu Bakış", *Tübitak Arkeometri Ünitesi Bilimsel Toplantı Bildirileri* VI, 1986, 131-153.

Esin 1987 — U. Esin, "Tepecik ve Tülintepe'ye (Altınova- Elazığ) Ait Bazı Metal ve Cüruf Analizleri", *ArkST* II, 1987, 69-79.

Finkbeiner et al. 2015 — U. Finkbeiner – M. Novák – F. Sakal – P. Sconzo, "Conclusion", in: U. Finkbeiner – M. Novak – F. Sakal – P. Sconzo (eds.), *Associated Regional Chronologies for the Ancient Near East and the Eastern Mediterranean Middle Euphrates* (Turnhout 2015) 431-438.

Frangipane 2017 — M. Frangipane, "The Role of Metal Procurement in the Wide Interregional Connections of Arslantepe during the Late 4th–Early 3rd Millennia BC", in: Ç. Maner – M.T. Horowitz – A.S. Gilbert (eds.), *Overturning Certainties in Near Eastern Archaeology, A Festschrift in Honor of K. Aslıhan Yener, Culture and History of the Ancient Near East,* Vol. 90 (Leiden 2017) 186–210.

Frangipane et al. 2002 — M. Frangipane – C. Alvaro – F. Balossi Restelli – G. Siracusano, "The 2000 Campaign at Zeytinli Bahçe Höyük", in: N. Tuna – J. Öztürk – J. Velibeyoğlu (eds.), *Salvage Project of the Archaeological Heritage of the Ilısu and Carchemish Dam Reservoirs. Activities in 2000* (Ankara 2002) 57-99.

Gil at al. 2000 — F.J. Gil – P. Charvát – M. Rothman – E. Algorri – E. Bucak, "1998 Salvage Excavations at Tilbes Höyük (Birecik, Urfa)", *Orient Express* 2000.2, 2000, 27-30.

Gale et al. 1985 — N.H. Gale– Z.A. Stos-Gale – G.R. Gilmore, "Alloy Types and Copper Sources of Anatolian Copper Alloy Artifacts", *An St* 35, 1985, 143-173.

Hauptmann 2007 — A. Hauptmann, *The Archaeometallurgy of Copper, Evidence from Faynan, Jordan,* (English edition) (Heidelberg 2007).

Hauptmann 2020 — A. Hauptmann, *Archaeometallurgy – Material Science Aspects* (Natural Science in Archaeology) (Switzerland 2020).

Hauptmann 1979 — H. Hauptmann, "Norşuntepe Kazıları, 1973", *Keban Projesi 1973 Çalışmaları/Keban Project 1973 Activities* (Ankara 1979) 43-60.

Hauptmann 1982 — H. Hauptmann, "Norşuntepe Kazıları, 1974", *Keban Projesi 1974-1975 Çalışmaları / Keban Project 1974-75 Activities* (Ankara 1982) 15-71.

Hauptmann 1985 — H. Hauptmann, "Lidar Höyük, 1984", *AnSt* 35, 1985, 203-205.

Hess et al. 1998	K. Hess – A. Hauptmann – H. Wright – R. Whallon, "Evidence of Fourth Millennium BC Silver Production at Fatmalı-Kalecik, East Anatolia", in: H.G. Bachmann – R. Maddin – T. Rehren – A. Hauptmann – J. Muhly (eds.), *Metallurgica Antiqua: in Honour of Hans-Gert Bachmann and Robert Maddin* (Bochum 1998) 57-67.
Kampschulte – Orthmann 1984	I. Kampschulte – W. Orthmann, *Gräber des 3. Jahrtausends v. Chr. im Syrischen Euphrattal: 1. Ausgrabungen bei Tawi 1975 und 1978* (Bonn 1984).
Koşay 1976	*H.Z. Koşay, Keban Projesi Pulur Kazısı 1968-1970 / Keban Project Pulur Excavations 1968-1970* (Ankara 1976).
Kunç et al. 1983	Ş. Kunç – A. Eker – S. Kapur – N. Gündoğdu, "Değirmentepe Cüruf Buluntuları Analizi", *Tübitak Arkeometri Ünitesi Bilimsel Toplantı Bildirileri* IV, 1983, 133-139.
Lamoni 2012	M. Lamoni, "Toggle Pins of the Bronze Age: A Matter of Style, Function and Fashion", in: F.M. Fales – G.B Lanfranchi – C. Pappi – S. Ponchia (eds.), *Leggo!: Studies Presented to Frederick Mario Fales on the Occasion of his 65th Birthday* (Wiesbaden 2012) 349-363.
Mallowan 1937	M.E.L. Mallowan, "The Excavations at Tall Chagar Bazar and an Archaeological Survey of the Habur Region. Second Campaign, 1936", *Iraq* 4, 1937, 91-177.
Mallowan 1947	M.E.L. Mallowan, "Excavations at Brak and Chagar Bazar", *Iraq* 9, 1947, 1-259.
Matney et al. 1997	T. Matney – G. Algaze – H. Pittman, "Excavations at Titriş Höyük in Southeastern Turkey: A Preliminary Report of the 1996 Season", *Anatolica* 23, 1997, 61-84.
McDonald et al. 2001	H. McDonald – J. Curtis – R. Maxwell-Hyslop, "Third-Millennium Metalwork", in: D. Oates – J. Oates – H. McDonald (eds.), *Excavations at Tell Brak Vol. 2: Nagar in the Third Millennium BC* (Oxford 2001) 233-256.
Montero-Fenollós 1999	J.L. Montero-Fenollós, "Metallurgy in the Valley of the Syrian Upper Euphrates During the Early and Middle Bronze Ages", in: G. Del Olmo Lete – J.-L. Montero Fenollos (eds.), *Archaeology of the Upper Syrian Euphrates. The Tishrin Dam Area. Proceedings of the International Symposium Held at Barcelona, Jan. 28th–30th, 1998* (Barcelona 1999), 443-469.
Müller-Karpe 1994	A. Müller-Karpe, *Altanatolisches Metallhandwerk* (Neumünster 1994).
Moorey – Schweizer 1972	P.R.S. Moorey – F. Schweizer, "Copper and Copper Alloys in Ancient Iraq, Syria and Palestine: Some New Analyses", *Archaeometry* 14, 1972, 177-198.

Moortgat 1965	A. Moortgat, *Tell Chuera in Nordost-Syrien Bericht über die vierte Grabungskampagne 1963* (Köln 1965).
Neukirchen 2016	F. Neukirchen, *Von der Kupfersteinzeit zu den seltenen Erden: Eine kurze Geschichte der Metalle* (Berlin 2016).
Nishimura 2015	Y. Nishimura, "A Systematic Comparison of Material Culture Between Household Floors and Residential Burials in Late Third-Millennium B.C.E. Mesopotamia", *AJA* 119.4, 2015, 419-440.
Novak 1994	M. Novak, "Gewandnade", in: J.-W. Meyer – A. Pruβ (eds.), *Ausgrabungen in Halawa 2. Die Kleinfunde von Tell Halawa A* (Saarbrücken 1994), 237-241.
Oates et al. 2001	D. Oates – J. Oates – H. McDonald, *Excavations at Tell Brak, 2: Nagar in the Third Millennium BC* (Oxford 2001).
Orthmann 1981	W. Orthmann, *Halawa 1977 bis 1979 Vorläufiger, Bericht über die 1. bis 3. Grabungskampagne* (Bonn 1981).
Orthmann 1989	W. Orthmann, *Halawa 1980-1986* (Bonn 1989).
Orthmann – Rova 1991	W. Orthmann – E. Rova, *Gräber des 3. Jahrtausends v. Chr. im Syrischen Euphrattal: 2. Ausgrabungen in Wreide* (Saarbrücken 1991).
Orthmann et al. 1995	W. Orthmann – R. Hempelmann – H. Klein – C. Kühne – M. Novak – A. Pruβ – E. Vila – H.M. Weicken – A. Wener, *Ausgrabungen in Tell Chuera in Nordost-Syrien. (I). Vorbericht über die Grabungskampagnen 1986 bis 1992* (Saarbrücken 1995).
Ökse 2006	A.T. Ökse, "Early Bronze Age Graves at Gre Virike (Period IIB): an Extraordinary Cemetery on the Middle Euphrates", *JNES* 65.1, 2006, 1-37.
Özbal 1983	H. Özbal, "Tepecik ve Tülintepe Metal, Filiz ve Cüruf Analizleri", *Arkeometri Ünitesi Bilimsel Toplantı Bildirileri* III, 1983, 203–218.
Özbal 1996	H. Özbal, "Chemical Analysis of a Copper Chisel from Hacınebi Tepe", *Anatolica* 22, 1996, 109-110.
Özbal et al. 1999	H. Özbal – A.A. Mieke – E. Bryan, "Hacınebi Metal Production and Exchange", *Paléorient* 25.1, 1999, 57-65.
Özbal – Turan 2002	H. Özbal – Ü. Turan, "Tilbeş Höyük ve Surtepe: M.Ö. 3. Binyılda Güneydoğu Anadolu Metalürjisi", *ArkST* 17, 2002, 59-69.
Özgen et al. 1997	Özgen – B. Helwing – H. Tekin, "Vorläufiger Bericht über die Ausgrabungen auf dem Oylum Höyük", *IstMitt* 47, 1997, 39-90.
Özgüç 1955	*T. Özgüç,* "*Koloni Devrinin Geç Safhasına* (Ib) *Ait Bir Atölye* Hakkında", *Belleten* XIX-73, 1955, 73-80.

Özgüç 2009	N. Özgüç, Samsat: Sumeysat, Samosata, Kumaha, Hahha, Hahhum: Bir Baskent ve Kalenin Uzun Yaşamının 6000 Yıllık Döneminden Kesitler (Ankara 2009).
Palmieri 1981	A. Palmieri, "Excavations at Arslantepe (Malatya)", *AnSt* 31, 1981, 101-120.
Palmieri – Di Nocera 2000	A. Palmieri – G.M. Di Nocera, "The Metal Objects from the "Royal" Tomb at Arslantepe (Malatya-Turkey) and the Metalwork Development in the Early Bronze Age", in: L. Milano – S. de Martino – F. Fales – G. Lanfranchi (eds.), *Landscapes, Territories, Frontiers and Horizons in the Ancient Near East* Part III (Padova 2000) 178-185.
Palmieri – Di Nocera 2004	A. Palmieri – G.M. Di Nocera, "Early Bronze Age Copper Circulation and Technology in the Middle Euphrates Regions", in: C. Nicolle (ed.), *Amurru 3: Nomades et sédentaires dans le Proche-Orient Ancient: Compte Rendu de la XLVIe Recontre Assyriologique Internationale, Paris, 10-13 juillet 2000* (Paris 2004) 377-388.
Peltenburg – Wilkinson 2008	E. Peltenburg – T.J. Wilkinson, "Jerablus and the Land of Carchemish: Excavation and Survey in Syria", *Current World Archaeology* 27, 2008, 24-32.
Pernicka et al. 1990	E. Pernicka – F. Begemann – S. Schmitt-Strecker – A.P. Grimanis, "On the Composition and Provenance of Metal Artefacts from Poliochni on Lemnos", *OxfJA* 9.3, 1990, 263-297.
Pfälzner 2001	P. Pfälzner, *Haus und Haushalt. Wohnformen des dritten Jahrtausends vor Christus in Nordmesopotamien, Damaszener Forschungen* Band 9 (Mainz 2001).
Porter 1995	A. Porter, "Tell Banat-Tomb I", *DaM* 8, 1995, 1-50.
Porter – McClellan 1998	A. Porter – T. McClellan, "The Third Millennium Settlement Complex at Banat: Results of the 1994 Excavations", *DaM* 10, 1998, 11-63.
Rothman 2002	M.S. Rothman, *Tepe Gawra: The Evolution of a Small, Prehistoric Center in Northern Iraq* (Philadelphia 2002).
Sagona 1994	A. Sagona, *The Aşvan Sites 3. Keban Rescue Excavations, Eastern Anatolia. The Early Bronze Age* (London 1994).
Schmidt 2002	K. Schmidt, *Norşuntepe: Kleinfunde II* (Mainz 2002).
Schmitt-Strecker et al. 1992	S. Schmitt-Strecker – F. Begemann – E. Pernicka, "Chemische Zusammensetzung und Bleiisotopenverhaltnisse der Metalfunde vom Hassek Höyük", in: M.R. Behm-Blancke (ed.), *Hassek Höyük Naturwissenschaftliche Untersuchungen und Lithische Industrie* (Tübingen 1992) 108-123.

Schwartz et al. 2006	G. Schwartz – H. Curvers – S. Dunham – B. Stuart – J.A. Weber, "A Third-Millennium BC Elite Mortuary Complex at Tell Umm el-Marra, Syria: 2002 and 2004 Excavations", *AJA* 110, 2006, 603-641.
Sertok – Ergeç 1999	K. Sertok – R. Ergeç, "A New Early Bronze Age Cemetery: Excavations near the Birecik Dam, Southeastern Turkey - Preliminary Report (1997-98)", *Anatolica* 25, 1999, 87-107.
Shalev – Northover 1993	S. Shalev – J. P. Northover, "The Metallurgy of the Nahal Mishmar Hoard Reconsidered", *Archaeometry* 35.1, 1993, 35-47.
Spuadrone 2007	F.F. Spuadrone, "Regional Culture and Metal Objects in the Area of Carchemish During the Early Bronze Age", in: E. Peltenberg (ed.), *Euphrates River Valley Settlement: The Carchemish Sector in the Third Millennium BC* (Oxford 2007) 198-213.
Spuadrone 2015	F.F. Spuadrone, "Metal", in: U. Finkbeiner – M. Novak – F. Sakal – P. Sconzo (eds.), *Associated Regional Chronologies for the Ancient Near East and the Eastern Mediterranean Middle Euphrates* (Turnhout 2015) 297-339.
Stein 1997	J.G. Stein, "1995 Excavations at Hacınebi Tepe", *KST* XVIII.1, 1997, 93-120.
Strommenger 1980	E. Strommenger, *Habuba Kabira, ein Stadt vor 5000 Jahren* (Mainz 1980).
Stork 2014a	L.A. Stork, "Is a Pin Mightier Than a Sword? Metal Items as Grave Goods During the Early Bronze I and II in the Upper Euphrates Valley", in: P. Bieliński – M. Gawlikowski – R. Koliński – D. Ławecka – A. Sołtysiak – Z. Wygnańska (eds.), *8th International Conference on the Archaeology of the Ancient Near East (ICAANE)*, Vol. 1 (Wiesbaden 2014) 539-548.
Stork 2014b	L.A. Stork, "The Relationship between Pins and Textiles in the Carchemish Region during the Early 3rd Millennium BC", in: R. A. Stucky – O. Kaelin – H.-P. Mathys (eds.), *Proceedings, 9th International Conference on the Archaeology of the Ancient Near East (ICAANE)*, Vol. 2 (Wiesbaden 2014) 323-332.
Stork 2014c	L.A. Stork, "On Pins and Needles: Understanding the Role of Metal Pins in the Upper Euphrates Valley During the Early Bronze I-II", *Levant* 46.3, 2014, 321-338.
Stork 2015	L.A. Stork, "Systems of Value and the Changing Perception of Metal Commodities, ca. 4000–2600 bc", *JNES* 74.1, 2015, 115-132.
Tadmor et al. 1995	M. Tadmor – D. Kedem – F. Begemann – A. Hauptmann – E. Pernicka – S. Schmitt-Strecker, "The Nahal Mishmar Hoard from the Judean Desert: Technology, Composition, and Provenance", *Atiqot* 27, 1995, 95-148.

Thureau-Dangin – Dunand 1936	F. Thureau-Dangin – M. Dunand, *Til-Barsib* (Paris 1936).
van der Stede 2005	V. van der Stede, "The Akkadian Occupation", in: M. Lebeau – A. Suleiman (eds.), *Tell Beydar / Nabada, An Early Bronze Age City in the Syrian Jezirah: 10 Years of Research (1992-2002)* (Damascus 2005) 33-37.
Woolley 1914	C.L., Woolley, "Hittite Burial Customs", *AnnLiv* 6, 1914, 87-99.
Woolley 1921	C.L., Woolley, *Carchemish. Report on the Excavations at Jerablus on Behalf of the British Museum. Part II: The Town Defences* (London 1921).
Yalçıklı – Tekinalp 2002	D. Yalçıklı – M. Tekinalp, "Mezraa Höyük 2000 Yılı Kazıları / Mezraa Höyük Excavations 2000". in: N. Tuna – J. Velibeyoğlu (eds.), *Ilısu ve Karkamış Baraj Gölleri Altında Kalacak Arkeolojik ve Kültür Varlıklarını Kurtarma Projesi 2000 Yılı Çalışmaları* (Ankara 2002) 159-210.
Yalçın – Yalçın 2008	Ü. Yalçın – H.G. Yalçın, "Der Hortfund von Tülintepe, Ostanatolien", *Anatolian Metal* IV, 2008, 101-123.
Yalçın – Yalçın 2009	Ü. Yalçın – H.G. Yalçın, "Evidence for Early Use of Tin at Tülintepe in Eastern Anatolia", *TÜBA-AR* 12, 2009, 124-142.
Zettler 1997	R.L. Zettler, "Surface Collections and Excavations in the Lower Town and Lower Town South", in: R.L. Zettler – J.A. Armstrong – A. Bell – M. Braithwaite – M.D. Danti – N.F. Miller – P.N. Peregrine – J.A. Weber (eds.), *Subsistence and Settlement in a Marginal Environment: Tell es-Sweyhat, 1989-1995 Preliminary Report* (Philadelphia 1997) 35-72.

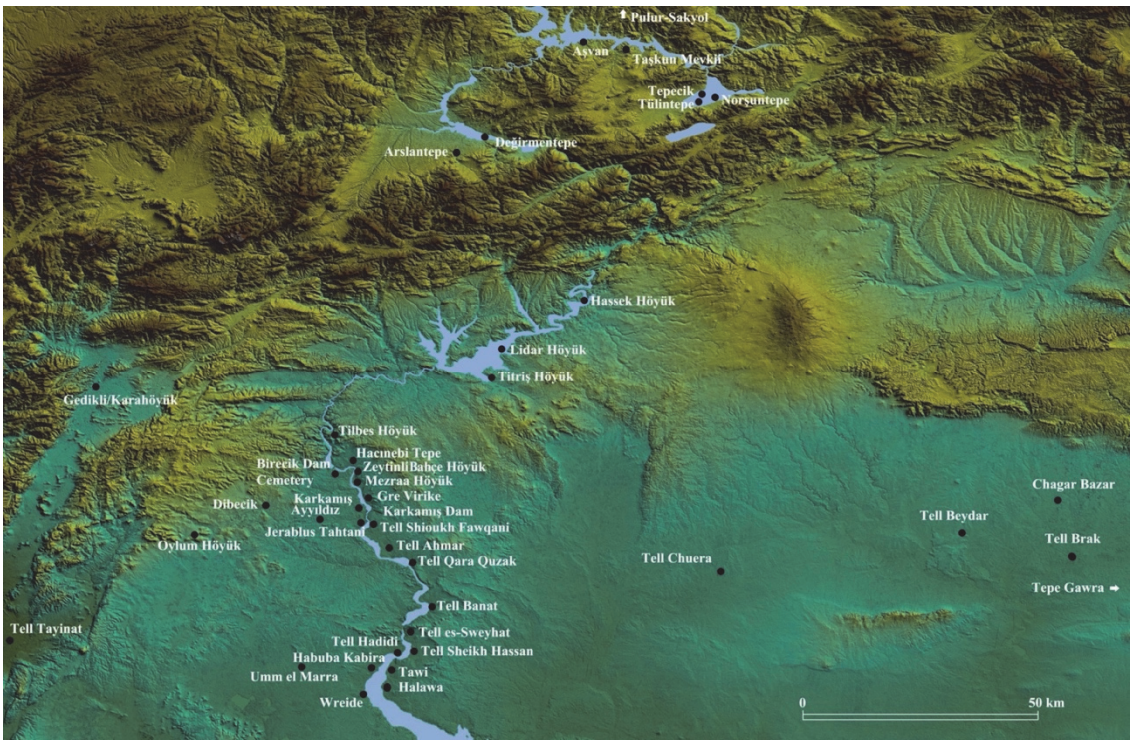

Figure 1

Figures	*Artefact*	*Konteks*	*Date*	*Probe* (CuO-NiO-As_2O_3) (Cu-Ni-As-Sn)			
					CuO	NiO	As_2O_3
Figures 2.1, 4.1	Crucible	0082V04	Early Bronze Age I (EME 2)	CuO-As_2O_3	88.34 95.15 78.45	--	2.58 3.26 1.80
Figures 2.2, 4.2	Crucible (piece 1)	7034V11	Early Bronze Age II (EME 2-3)	CuO-As_2O_3	52.76 50.85 57.93	--	0.43 0.48 1.05
Figures 2.2, 4.2	Crucible (piece 2)	7034V11	Early Bronze Age II (EME 2-3)	CuO-NiO-As_2O_3	88.22 62.71 73.72	2.79 2.14 1.35	0.61 2.70 0.87
					Cu	Ni/Sn	As
Figures 2.3c, 4.3c	Pins	5500V02	Early Bronze Age III (EME 4)	Cu- Ni-As	93.8	0.047 (Ni)	2.25
Figures 2.3d, 4.3d	Pins	4550V01	Early Bronze Age III/IVA (EME 4-5)	Cu-Sn	92.7	3.86 (Sn)	0.032

Tablo 1

Figure 2

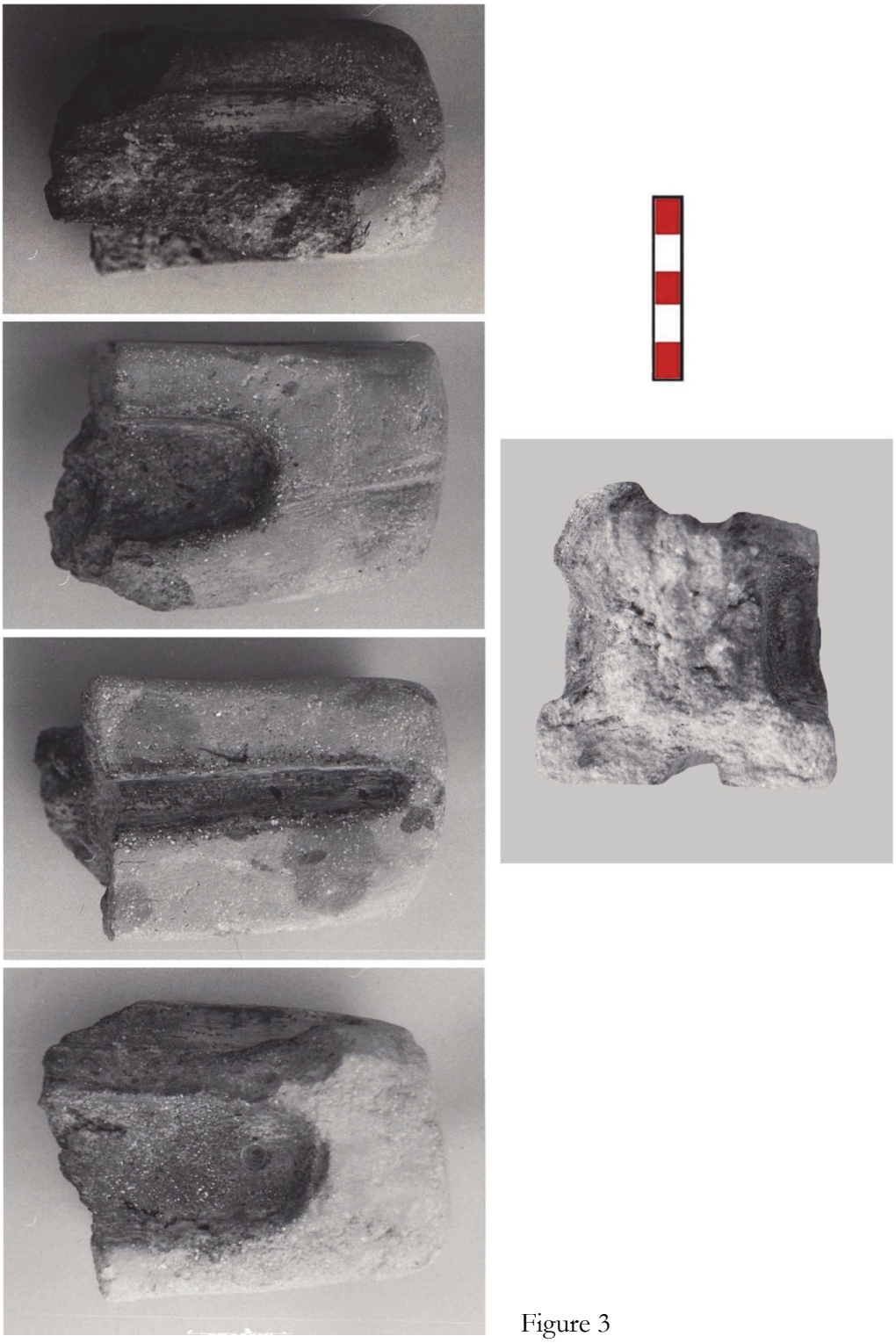

Figure 3

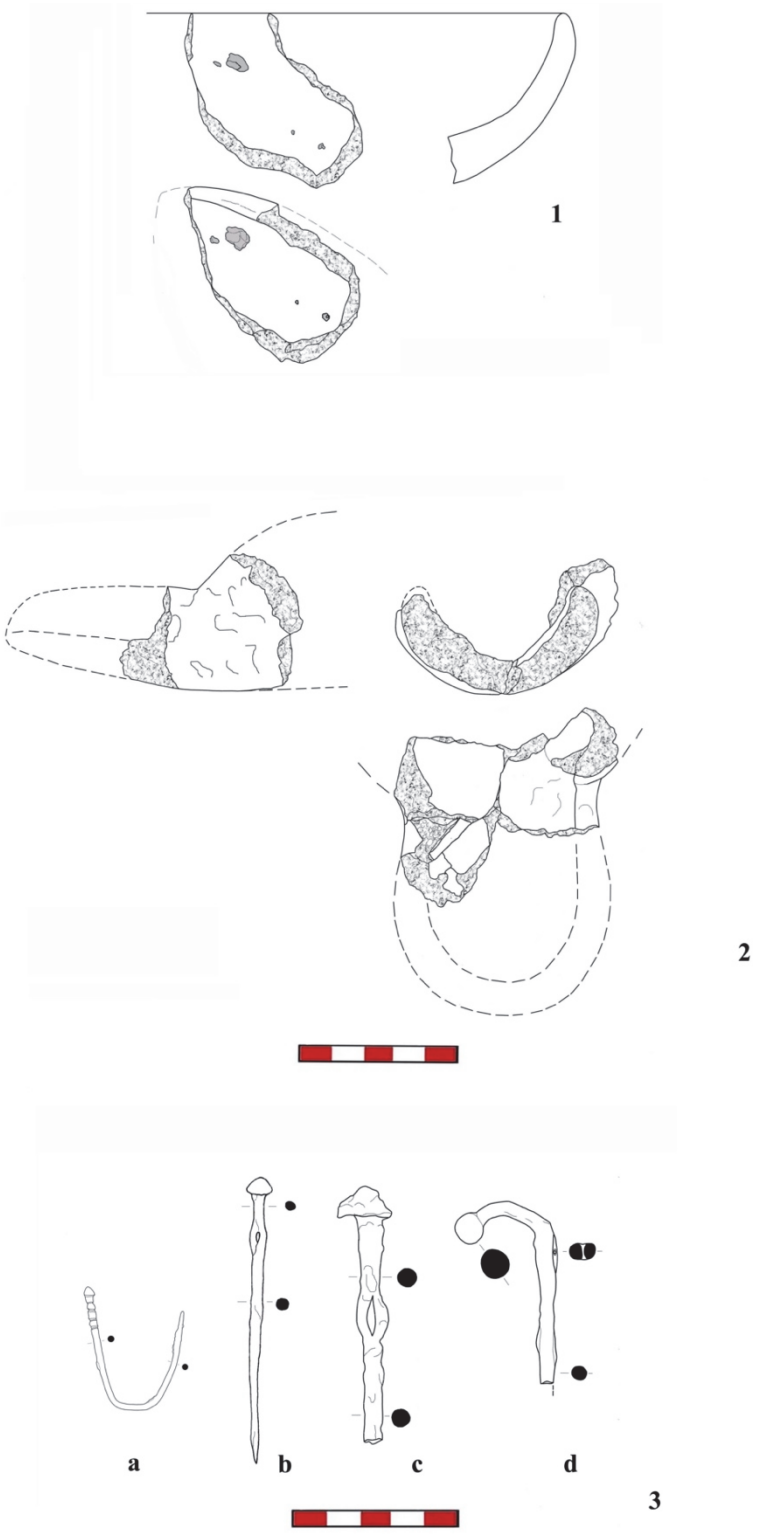

Figure 4

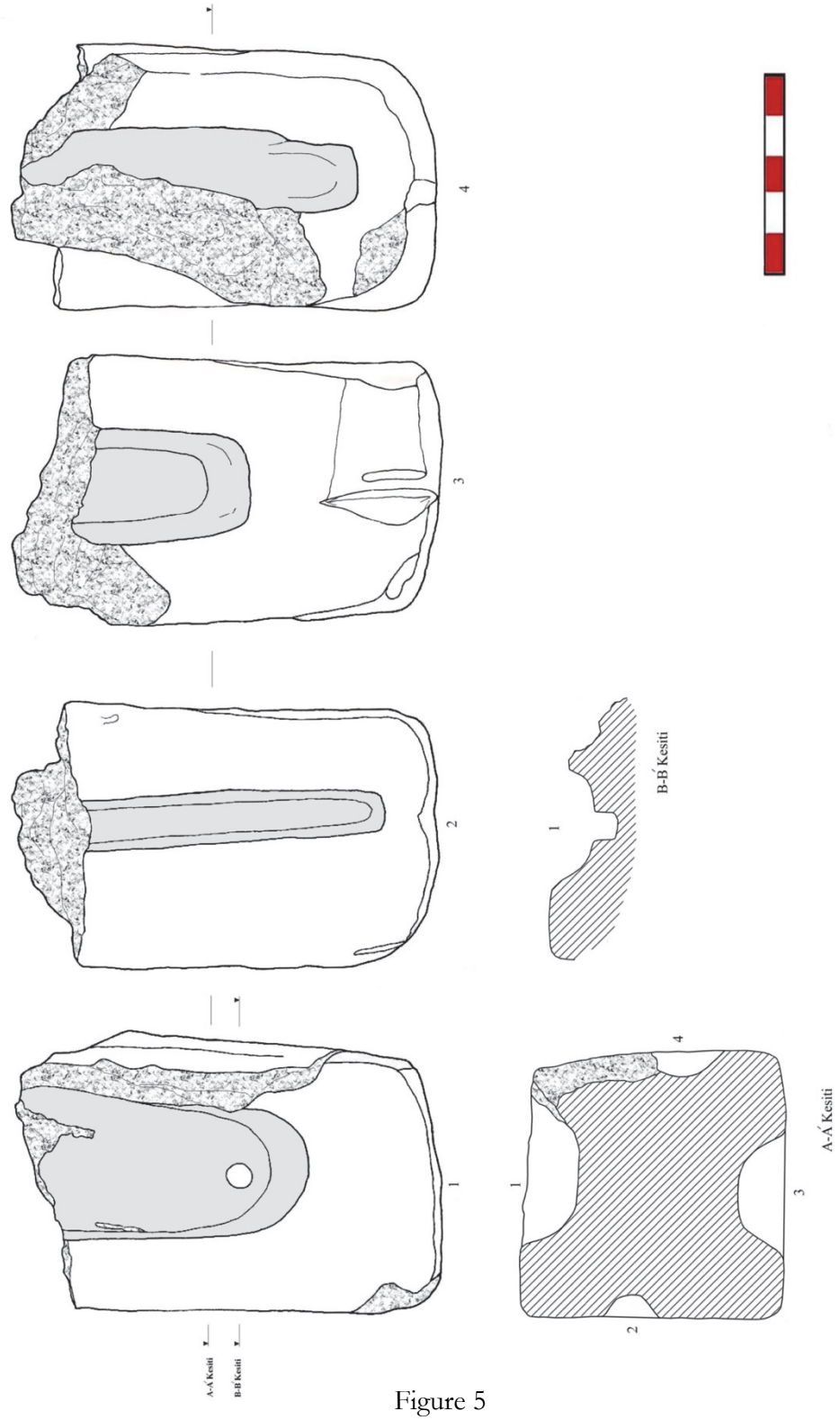

Figure 5