EARLY BRONZE AGE METALLURGY AT MURAT HÖYÜK, EASTERN ANATOLIA: ARCHAEOMETRICAL ASSESSMENTS OF A FIGURINE AND A METAL TOOL

DOĞU ANADOLU'DA MURAT HÖYÜK'TE İLK TUNÇ ÇAĞI METALÜRJİSİ: BİR FİGÜRİNİN VE BİR METAL ALETİN ARKEOMETRİK YÖNTEMLERLE İNCELENMESİ

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ABSTRACT

Murat Höyük lies on the bank of the Murat River in Solhan district of Bingöl province in Eastern Anatolia. This study presents archaeometrical analyses of a unique metal figurine and a metal tool recovered in situ during the 2019 Murat Höyük Excavations, the first systematic archaeological excavation project in Bingöl. Four cultural layers (Medieval, Middle Iron, Early Iron, and Early Bronze Age) were documented at the site, where the earliest settlement is dated to the EBA III (2500-2200 BC). The metal figurine and tool were found in this earliest phase (IV), where stone mould fragments and a crucible were also found in associated contexts. Portable XRF (p-XRF) analyses performed on the figurine, and p-XRF and metallography analyses conducted on the copper tool revealed that metals used in the manufacture of these artefacts were smelted from different polymetallic copper ores. Additionally, production process of the objects was examined in this study. A holistic evaluation of finds related with metallurgy at Murat Höyük reflects cultural affiliation with the Upper Euphrates Basin in terms of material choice and production technology. The present study on Murat Höyük metal finds provide new insight into Early Bronze Age metallurgy, belief systems, and art in Eastern Anatolia.

Keywords: Eastern Anatolia, Bingöl, Early Bronze Age, Figurine, Copper Metallurgy, Archaeometry.

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ÖZET

Murat Höyük, Doğu Anadolu Bölgesi, Bingöl İli Solhan İlçesi'nde, Murat Nehri kenarında yer almaktadır. Bu çalışma, Murat Höyük'te 2019 yılında yapılan Bingöl'ün ilk sistemli arkeolojik kazısı sonucunda ele geçen ünik bir metal figürinin ve bir metal aletin arkeometrik analiz sonuçlarını tanıtır. Arkeolojik kazılar sonucunda höyükte Orta Çağ, Orta ve İlk Demir Çağ ve İlk Tunç Çağ olmak üzere dört kültür tabakası tespit edilmiş olup, en erken tabaka İlk Tunç Çağı III'e (MÖ 2500-2200) tarihlenmektedir. Çalışma kapsamında incelenen metal figürin ve alet, en erken kültür tabakasında (IV), metal üretimiyle ilişkili döküm kalıbı parçaları ve kilden bir pota ile birlikte aynı kontekste ele geçmiştir. Figürinin yüzeyinde gerçekleştirilen taşınabilir XRF (p-XRF) analizleri ve bakır alette yapılan p-XRF ve metalografi analizleri, bu eserlerin üretiminde kullanılan metallerin farklı polimetalik bakır cevherlerinden elde edildiğini ortaya çıkarmıştır. Ayrıca, bu analizler sonucunda nesnelerin üretim ve şekillendirme süreçleriyle ilgili veriler elde edilmiştir. Figürin ve aletin, metal üretimi ile ilgili diğer buluntularla birlikte değerlendirilmesi, malzeme seçimi ve üretim teknolojisi açısından Yukarı Fırat Havzası ile kültürel bağlılık olduğunu göstermektedir. Murat Höyük metal buluntuları üzerine yapılan bu çalışma, Doğu Anadolu'daki İlk Tunç Çağı metalürjisine, inanç sistemlerine ve sanatına yeni bir bakış açısı sağlayacaktır.

Anahtar Kelimeler: Doğu Anadolu, Bingöl, İlk Tunç Çağı, Figürin, Bakır Metalürjisi, Arkeometri.

INTRODUCTION

Murat Höyük lies on the bank of the Murat River in Solhan district of Bingöl province in Eastern Anatolia (Fig. 1). The mound is located within the boundaries of Murat köy, the nearby village after which the archaeological site is named. Because the site lies within the water reservoir of Aşağı Kaleköy hydroelectric dam, official action was taken for Murat Höyük to be recognized as a threatened site before the completion of the dam, and salvage excavations were conducted at the site in 2019. Murat Höyük Excavations Project is the first systematic archaeological excavation ever carried out in Bingöl province. Phase IV, the earliest of the four cultural layers documented by excavations at the site, is dated to Early Bronze Age III (2500-2200 BC) in the relative culture-historical sequence of Eastern Anatolia. This date is confirmed by two 14C samples from Phase IV (Özdemir 2020: 277): carbonized wood remains from a building, calibrated to 2499-2396 BC, cal. 2α (Tubitak-0842: 3951±27 BP), and carbonized grains from an in-situ jar found in Room 4, calibrated to 2348-2189 BC, cal. 2α (Tubitak-0834: 3812±30 BP), (Özdemir and Özdemir 2020: 134). Early Bronze Age (Phase IV) is followed by three more cultural strata dating to the Early Iron Age (Phase III), Middle Iron Age (Phase II), and Byzantine Period (Phase I). Extant evidence shows that Murat Höyük was repeatedly resettled with periods of abandonment in between.

Phase IV settlement spreads over the south and southeast portions of the site, just along the riverbank. Architectural remains are characterised by rectangular single-room structures built from mudbrick on stone foundations. An open courtyard area, where daily activities were carried out, was uncovered in between architectural structures. Installations such as a stone-paved bench with scattered pestles and grinding stones nearby, and a circular hearth unearthed in this courtyard demonstrate that collective food preparation and consumption activities were carried out in this area. Additionally, other finds such as a clay crucible for smelting and stone moulds for casting metal objects found in this courtyard and vicinity suggest that the Early Bronze Age community of Murat Höyük also carried out metallurgical activities and metalworking on-site.

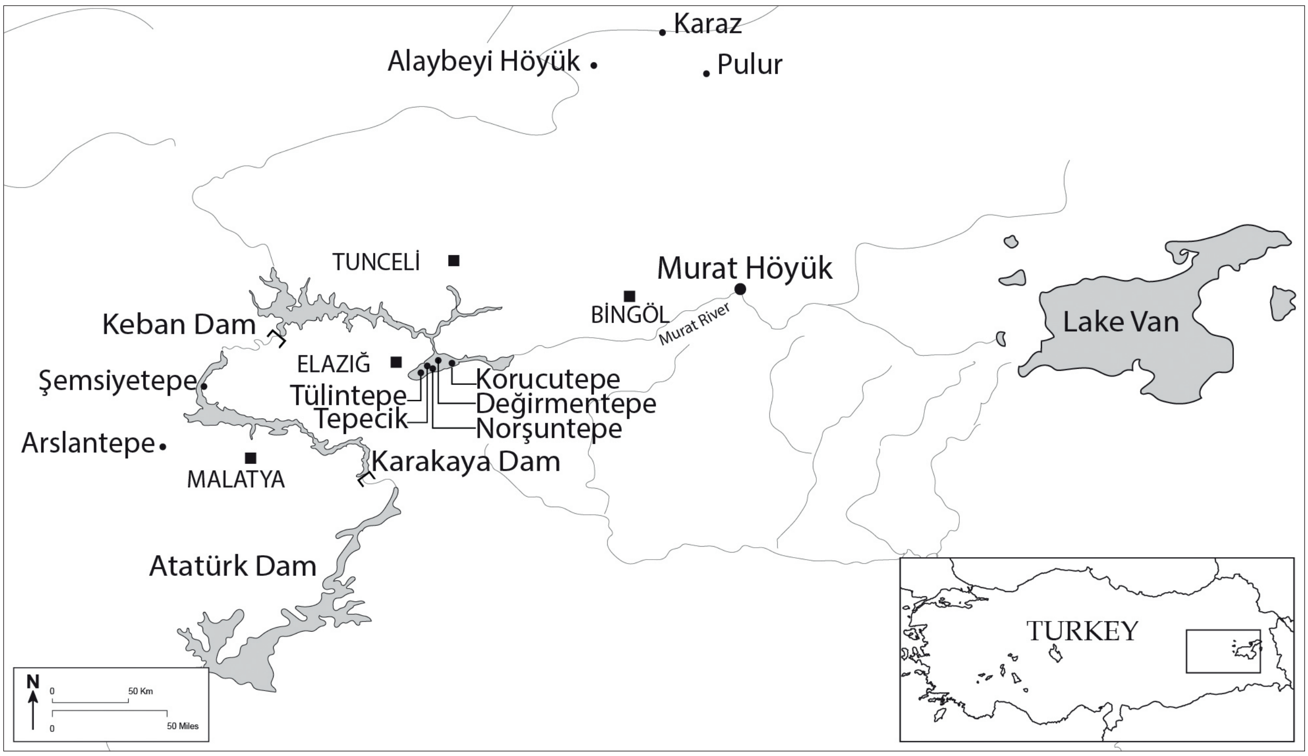

Figure 1. Map of major Early Bronze Age sites in Bingöl and vicinity, showing the location of Murat Höyük (Illustration: A. Onur BAMYACI) / *Bingöl ve çevresindeki başlıca İlk Tunç Çağı yerleşimlerini ve Murat Höyük'ün konumunu gösteren harita (Çizen: A. Onur BAMYACI).*

The two finds which were sampled for archaeometrical analyses presented in this study are an Early Bronze Age metal figurine and a metal perforator found in the courtyard. Here, we evaluate the instrumental analysis results, material properties, and production techniques of these two objects, in conjunction with other archaeological evidence on metallurgical activities from the same phase including a crucible and fragments of stone moulds.

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SAMPLED MATERIALS

All materials sampled and discussed in this study originate from the Phase IV settlement level of Murat Höyük and were recovered in situ in the courtyard located to the east of Wall 1 in grid square T19 (Fig. 2). This level is dated to Early Bronze Age III (2500-2200 BC) on the basis of 14C analysis, as well as comparative analysis of material culture remains including typical local pottery forms of the EBA III repertoire, Karaz (Kura-Araxes) pottery, and ground-stone tools.

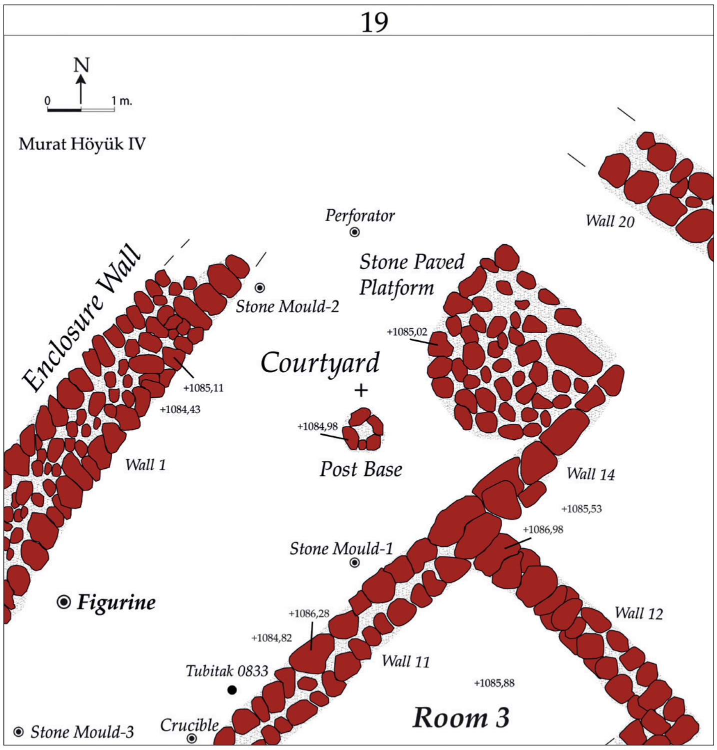

Figure 2. Murat Höyük Phase IV plan showing the location of sampled finds / *Murat Höyük IV nolu evreye ait planda, çalışmada incelenen buluntuların konumu.*

The most significant find recovered from Phase IV is an intact metal figurine (Excavation Inv. No. MH19-201), depicting a standing female nude (Fig. 4). Details are not emphasised on the body, except for the pubic triangle that is indicated with incised lines. The hips are slightly protruding; one of the breasts is relatively flat, while the other one is pronounced in low relief. Hands and feet are highly stylised; both arms are stretched out with the left arm slightly bent forward and the right arm extending sideways. Facial details are not distinct; eyes are shown as shallow depressions, while the mouth is not indicated at all. The head is slightly tilted to the left and is adorned with a headdress. Metric measurements of the figurine are as follows: height: 5.7 cm, width: 3.23 cm, thickness: 0.95 cm, and weight: 24.35 grams (Özdemir and Bamyacı in press).

In the archaeological record of Anatolia, the most well-known figurines of the Early Bronze Age II period are found at Alacahöyük (Kosay 1938: 83; Lev. LXXXIX, 38; Kosay and Akok 1973: Lev. LXVI, Al.n. 223; Kulaçoğlu 1992: No. 97, 96, 98), Hasanoğlan (Dolunay 1960: 81), and Horoztepe (Özgüç and Akok 1958). It is interesting to note that, the most notable figurines of the late Early Bronze Age III period, such as the 'nursing mother' figurine from Horoztepe and bronze figurines from Alacahöyük Royal Tombs, are standing female figurines (Aydıngün 2005: 73). The standing naked female figurine from Murat Höyük is depicted with outstretched arms, and the pubic area is emphasised in relief and with incised grooves. Alacahöyük and Horoztepe metal figurines are also naturalistic depictions with balanced body-to-limb proportions, mostly naked and in standing pose (Bilgi 2012: 306).

The metal tool (Excavation Inv. No. MH19-69) recovered in the Phase IV courtyard nearby the metal figurine has a circular cross-section tapering towards a pointed tip and it terminates in a blunt end (Fig. 5). The thicker posterior end of the object was bent due to usage. Therefore, it is thought that this tool was used as a perforator or awl for piercing soft materials such as leather. Its preserved length is 6.2 cm; its thickness varies from 0.2 cm to 0.3 cm; and it weighs 4.41 grams.

An important find related to metal production in this settlement phase at Murat Höyük is a small crucible made of clay. The crucible has an oval chamber. Its spout would have been located on its short side has not survived, and the object was restored as a closed form by conservators before it was recognised as a crucible (Fig. 3). The maximum depth of the oval chamber is approximately 2 cm. Its maximum diameter along the long axis is 8.59 cm (including wall thickness), and the minimum diameter along the short axis is 5.81 cm (excluding wall thickness). Assuming that the inner chamber of the crucible is half of a regular ellipsoid, if we take the assumed density of copper at the melting point (1084 °C) as 8 gr/cm3 (Kurochkin *et al.* 2013: 199), it may be estimated that the crucible could hold 316 grams of molten copper. In practice, however, the copper charge to be melted should have been much less than this amount with respect to the level of the spout. The most striking feature of the Murat Höyük crucible is the two high projections placed on the rim on one of the long sides. With these projections with rounded tips, the height of the crucible reaches 6 cm. These extensions were probably intended for attaching a handle to assist in removing the crucible from the hearth and pouring the molten charge in the crucible into a mould. Although crucibles with an oval chamber and a spout are attested across a wide geography since the Late Chalcolithic, crucibles with two extensions on the rim are known from very few archaeological sites. An example is known from Stratum IV at Tepe Gawra, dating to the early 2nd millennium BC, where the object was identified as a lamp by Speiser (1935: 59). The lateral extensions in this example are short and connected to the body with a slight inclination. Similarly, another example with short extensions is among the Middle Bronze Age finds of Norşuntepe (Schmidt 2002: 50). The closest examples to Murat Höyük crucible, in terms of the proportions of the extensions and the time period, are two crucibles found at Arslantepe - Malatya (Frangipane 2004: 201). The only difference of these crucibles unearthed at Arslantepe in Level VID, which is dated to the Early Bronze Age III (2500-2000 BC) period, is that the extensions point sideways rather than upwards.

Figure 3. Crucible from Phase IV: (a) lateral view, (b) top view / *IV nolu evrede ele geçen pota; (a) yandan görünüm, (b) üstten görünüm.*

Another remarkable group of finds that constitute direct evidence for on-site metalworking at Murat Höyük Phase IV are stone moulds unearthed in situ in the courtyard in T19. Three mould fragments were found here that exemplify the skilled craftsmanship of ground stone industry in this period. The moulds were formed from volcanic basalt and granite by cutting, carving, scraping, and finally grinding for finishing the surfaces. The contours of the negative impression in the moulds indicate that all three moulds were used in the production of metal axes. Comparative analyses with EBA moulds and weapons from other sites revealed that individually shaped shaft-hole axes were cast in these moulds. One of the moulds has a groove decoration on the outer surface of the socket for the haft.

ANALYTICAL METHODS AND RESULTS

In order to determine the chemical characterisation of the materials from which the figurine MH19-201 and the perforator MH19-69 were produced, we preferred to analyse the finds with a portable X-ray Fluorescence (p-XRF) device. Since the figurine (MH19-201) is a unique artifact, permissions were restricted to non-destructive analytical techniques. P-XRF equipment is a portable device that provides the measurement of major and minor elements in the chemical composition of archaeological finds in museum collections and at archaeological sites (Shugar and Mass 2012: 17-20). Because the p-XRF analysis can be conducted on-site where the artefacts are located and does not require any sample preparation procedures, it has become a widely used method in archaeometry studies. However, p-XRF analyses performed in low-voltage and vacuum-free environments have lower sensitivity compared to instrumental analyses in controlled laboratory environments. Also, since the measurements are performed on the surface of the object, contamination from soil deposits or applied conservation materials may affect the analysis results (Craddock 2009: 137). Additionally, the corrosion layers covering the surface of the finds might have different chemical compositions than the composition of the original metal (Lutz and Pernicka 1996: 316). Nevertheless, if analyses are conducted with the p-XRF with an awareness of its limitations, the method has a great potential to provide significant information about material properties and production techniques of archaeological artefacts, especially those in museum collections that cannot be analysed with destructive methods (Güder *et al.* 2020).

For the XRF analysis of the figurine and the perforator, a portable Spectro X-Sort Combi device was used in

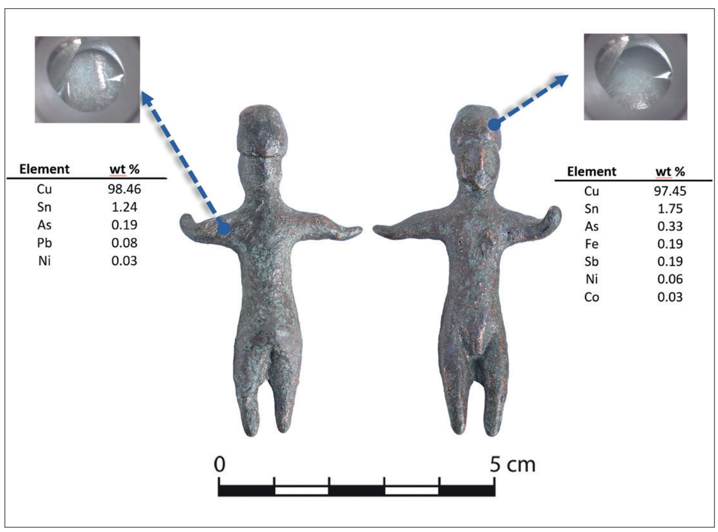

Figure 4. Locations selected for analysis on the surface of the metal figurine and the images captured with the internal camera of the p-XRF device. (In the reported analysis results, elements with percentages lower than the detection limit were excluded, and the weight percentages of the remaining elements were normalized to 100%) / *Metal figürin üzerinde analiz için seçilen bölgeler ve p-XRF cihazının iç kamerasından elde edilen bu bölgelere ait görüntüler (Kompozisyon içerisindeki yüzdeleri tespit limitlerinin altında kalan elementler analiz sonuçları dışında bırakılmış olup, geriye kalan ağırlık yüzdeleri %100'e normalize edilmiştir.).*

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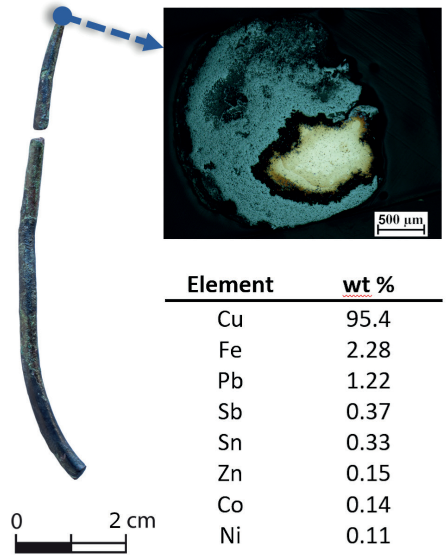
light elements mode (50 kV voltage, 0.016 mA current, and 12 seconds measurement time). The device has a self-calibration function that utilises measurements of a standard metal embedded on the inner surface of the detector cover. Calibration process was carried out using this function before measurements were taken from both objects. Since the figurine was mechanically cleaned by conservators prior to analysis, the metallic copper colour was visible on the surface in certain parts. First, the surface of the finds was examined using the internal camera of the p-XRF device in order to select areas where the original surface of the artifact is exposed. On the figurine, two areas were identified for analysis where the metallic colour could be seen, one located on the head and the other on the back of the figurine (Fig. 4).

The surface of the perforator MH19-69 is covered with a thick corrosion layer (patina). Upon our initial examination, the surface of this artefact appeared to be covered entirely by a corrosion layer with no exposure of the original metallic surface for viable analysis. The p-XRF analysis performed at several points on the patina-covered surface of the object detected, besides copper (Cu), an average of 5.65% lead (Pb) and 2.44% arsenic (As). Since the composition of the patina layer was expected to be different from the original metal that the tool was made of, the tip of the tool was also sampled. A small sample was sliced off from the tip of the tool using an air-cooled diamond disc, after which the sample was embedded in epoxy. Following established metallography sample preparation protocols, the sample was ground with SiC papers and polished with diamond solutions. After etching, the sample was examined with a Nikon E-Pol 200 light microscope and metallography images were taken with a digital camera. The light microscopy photograph in Figure 4 represents the cross-section of the tool. As the digital image of the cross-section shows, the original metal component was severely corroded; however, the original surface could be captured in a small area, where the metallic copper colour is visible (Fig. 5). Results of the p-XRF analysis performed on this cross-section differ from the results obtained from the surface. The cross-section sample has less amount of lead (Pb) and no arsenic (As). Also, the detected amount of iron (Fe) is different in the cross-section, and these elements are accompanied by low proportions of antimony (Sb), tin (Sn), zinc (Zn), cobalt (Co), and nickel (Ni).



Element	wt %
Cu	95.4
Fe	2.28
Pb	1.22
Sb	0.37
Sn	0.33
Zn	0.15
Co	0.14
Ni	0.11

Figure 5. Sampled location on metal tool MH19-69, showing the metallography image of the cross-section captured with light microscope. Reported weight percentage of the elements is normalized to 100% / *Metal aletin (MH19-69) numune alınan bölgesi ve bu numunenin kesitinden ışık mikroskobu ile elde edilen metalografi görüntüsü. Tabloda belirtilen ağırlık yüzdeleri %100'e normalize edilmiştir.*

EVALUATION OF ANALYTICAL RESULTS

Metal finds from the Early Bronze Age III settlement phase of Murat Höyük are limited to the two objects analysed in this study. Of these two objects, the metal figurine is worthy of closer attention. Casting burrs and flash lines visible on the surface of the figurine indicate that it was cast in a two-piece clay mould, and the sprue (i.e., the channel for pouring the molten metal) was located on one side of the headdress. Upon a closer look, casting defects in the form of small concave pores are also visible on the surface, which result from the bubbles that gases trapped in the mould form during casting. The reason for the pores to occur is the lack of sufficient arsenic or tin in the composition of the molten metal to act as a deoxidation agent, which results in the formation of large amounts of copper oxide compounds and the reaction of these oxides with hydrogen (Figueiredo *et al.* 2011: 327). In fact, the positive effect of arsenic on the workability and castability of copper was understood since the Late Chalcolithic Age and was applied in alloys. (Tylecote 1992: 10). Considering the presence of large gas pores observed on the chest of the figurine, the uneven proportions of the breasts may also be understood as a casting defect (Fig. 4). After the figurine was removed from the mould, especially the upper parts of the body were further retouched. Casting burrs on both sides of the body and head and sprue residues on the headdress were scraped off. However, a notable burr close to the pubic area between the legs was not removed. An interesting parallel is seen at Early Bronze Age Alacahöyük, where the casting burr in the pubic area of a silver-copper alloy figurine (11702) from Tomb A1 was likewise left untouched (Yalçın and Yalçın 2013: 40). Analyses of this Alacahöyük figurine revealed gold attached to the surface of the burr, which led to the conclusion that the figurine (or its particular features) were originally gold-plated. However, in our case, no evidence of a different type of metal was detected on the surface of the Murat Höyük figurine.

Examination of the arms reveal further details about the production sequence. Originally, when the figurine was removed from the mould, both arms were stretched out to the sides. The left arm was then retouched and bent forward by hammering the spots near the shoulder from the back with a hard tool. The fact that the hammering marks are still observable on the back of the arm indicates the find was not heated during hammering (Fig. 4).

In the composition of the metal from which the figurine was produced, the most abundant element after copper is an average of 1.50% tin. Other elements detected do not exceed 0.33%. Because these measurements are based on p-XRF measurements from the surface of the artefact, they need to be interpreted with due consideration. In particular, the low amount of tin in the composition raises doubts as to whether a deliberate tin alloy was produced. In this regard, Tylecote (1991) has suggested that, if the total of the alloying elements in the chemical composition of the analysed metal object is below 4%, these elements should be considered natural inclusions in a polymetallic ore, rather than an indication of intentional alloying. Also, since tin addition below 5% does not make a significant change in the physical properties and appearance of a copper alloy, this ratio can be accepted as the lower limit of the definition of tin bronze (Eaton and McKerrell 1976: 180). In light of these evaluations, we should accept that the tin in the figurine was not deliberately mixed. The results of composition analyses conducted on metal objects from key Early Bronze Age settlements in Anatolia show that a considerable number of tools were produced from copper alloys containing 0.50-3.0% tin. In fact, even metal objects from earlier periods yield a similar tin ratio, as exemplified by four objects from Yümüktepe and three objects from Tilmen Höyük, dating to the Chalcolithic Period, which have yielded tin ratios between 0.57% and 2.6% (Esin 1969). We may also cite a needle (T70.157) with 1.2% tin content among analysed metal objects from the key Early Bronze Age sites of Tepecik and Tülintepe (Çukur and Kunç 1989: 115). Additionally, p-XRF analysis of an Early Bronze Age flat axe (Inv. 70 tkmc) from Norşuntepe, which we analysed as part of another study concerned with compositional analyses of metal artefacts in Elazığ Museum collections, yielded a similar result (avg. 1.47% Sn in weight). These data show that Early Bronze Age metallurgists in Eastern Anatolia procured copper from polymetallic ores, which, in some cases, contained tin.

An overview of anthropomorphic Early Bronze Age figurines from Anatolian sites shows that most often the figurines were either made from or coated entirely or partially with precious metals, while some examples were also adorned with attachments made of precious metals. Two of the six figurines from Alacahöyük 'royal tombs' were cast from silver-copper alloys, while the remaining four were cast from copper alloys. In one of the copper-alloy figurines (7026), tin and lead were detected in different ratios in the figurine's body and in the jug that it holds in its hands. Another bronze figurine (7027) from Alacahöyük was suggested to be an imported object, since its metal composition contains approximately 6% antimony, which is unusual in comparison to other metal finds from the site (Yalçın and Yalçın 2013). Hasanoğlan figurine is another well-known specimen of Anatolian Early Bronze Age metallurgy, recognised for its highly skilled casting technique and its ornamental attachments. The body of the figurine is cast from silver and its entire head and neck are coated with gold sheet. The figurine is adorned with two diagonal straps across its chest and delicately formed anklets, also shaped from gold. P-XRF analysis of the Hasanoğlan figurine revealed that metal used for the body is an alloy of silver with a small but significant amount of copper, and gold sheet for the ornaments was alloyed with silver (Zimmermann and Özen 2016: 20). No compositional analysis has been conducted on the 'nursing mother' figurine from Horoztepe, which also comes from a funerary deposit. The colour of the surface, as it appears in photographs, suggest that the body of this figurine was produced from a copper alloy (Kulaçoğlu 1992: fig.103). Casting porosity on various parts of the surface and a casting burr on one shoulder are noticeable.

Analytical results show that the figurine and the perforator from Murat Höyük have distinct chemical compositions, which implies that the two objects were made from metal ores originating from different sources. In the analysis of the tool, the amount of lead (Pb) detected on the surface was different than the lead content in the cross-section where the metal core is exposed. The fact that lead was detected in higher amounts on the surface is due to the enrichment of elements with high electronegativity in the patina layer (Craddock 2009: 137). The amount of lead in the cross-section, which is expected to approximate the original metal composition, is as low as 1.22%. This amount could be reached by smelting copper ores that naturally contain lead-rich minerals. In fact, since lead-alloying has a softening effect on copper (Moorey 1969: 144), it is highly unlikely that the manufacturers of this tool would have intentionally added lead to copper. Surprisingly, on the other hand, 2.28% iron was detected in the cross-section of the tool. This result is significant, because although iron content detected in copper-alloys from the Bronze Ages do show an increase

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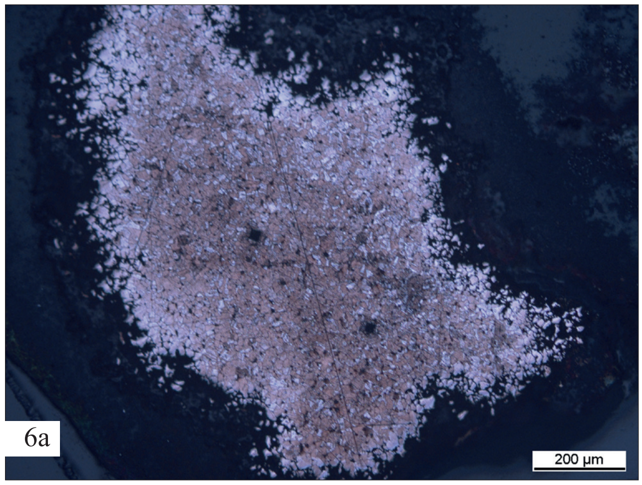
compared to earlier prehistoric periods, it does not exceed 1% (Craddock 2000: 154). In objects with high iron content from the actual Iron Age, iron is observed as a distinct metallic phase within the copper-dominated microstructure (Cooke and Aschenbrenner 1975: 258). In the metallographic examination of the Murat Höyük tool, only a small region of metal, which could resist to corrosion, was noticed in the core of the sample (Fig.6.a). With a closer look, no distinct metallic phase formation of iron was observed. Instead, a large number of black-coloured inclusions with angular forms were detected inside the microstructure (Fig. 6.b).

It is possible that these angular inclusions, which are residues of smelting slag and unreacted ore, are rich in iron, resulting in the high iron content of measurement (Figueiredo *et al.* 2011). This possibility would also explain why iron does not appear as a distinct phase in the metallography image, although its presence is detected by the p-XRF device. More information on the mineralogy of the ore from which the metal was produced can be obtained if the chemistry of the inclusions can be examined in depth. For example, if these intermetallic inclusions contain in sulphur together with iron, it can be inferred that the main copper-containing mineral inclusion in the smelted metal is chalcopyrite (CuFeS2) and that the mineral galena (PbS) mixed with chalcopyrite is also present. Chalcopyrite is frequently found together with pyrite forms containing lead (Pb), arsenic (As), antimony (Sb), bismuth (Bi) and nickel (Ni) (Hauptmann 2020: 41). Chemical analyses of slag samples and elevated amounts of elements mentioned above in the metal composition of the artefacts at Norşuntepe indicate that, sulphur-rich ores came into use with the onset of the Early Bronze Age at the site (Pernicka *et al.* 2002: 125). Additionally, we may point out that, lead in the metal composition of Norşuntepe finds does not exceed 1.21% except for one sample. This data supports the idea that the lead in these metals was not added deliberately (Pernicka *et al.* 2002: 135). Along parallel lines, we propose that lead detected in the Murat Höyük tool comes from the natural inclusions in the polymetallic copper ore that the tool was manufactured from.



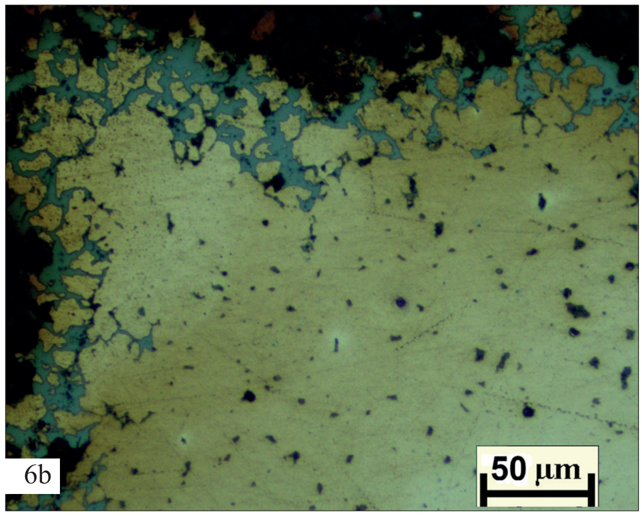


Figure 6.a) In the metallography image of the sample from metal tool MH19-69, a small metal region surrounded by thick corrosion layer can be seen. b) In the same sample, grey-coloured inter-granular corrosion borders the small grains of copper. Intermetallic compounds can be observed inside the copper / *a) Metal alet (MH19-69) numunesine ait metalografi görüntüsünde, kalın bir yenim (korozyon) tabakasının metal bölgenin etrafında yer aldığı görülmektedir. b) Aynı örnekte gri renkte tanelerarası yenim küçük bakır tanelerini çevrelemektedir. Bakır içerisinde intermetalik kalıntılar gözlenmektedir.*

DISCUSSION

Southeast Anatolia has rich copper deposits spread across the region in a crescent-shaped belt extending from the Amanus Mountains in the west to Siirt province in the east (Özbal *et al.* 1999). Two of the most significant deposits on this belt are located at Ergani and Keban, only 200 km away from Murat Höyük. These mines played a great role in the emergence and development of copper metallurgy in early prehistory (Seeliger *et al.* 1985: 598). In the vicinity of Murat Höyük, the closest copper-rich deposit is located within the boundaries of Çobançeşmesi village in Genç district, about 72 km southwest of the mound (for location, see https://www.mta.gov.tr/v3.0/sayfalar/bilgi-merkezi/maden_potansiyel_2010/Bingol_Madenler.pdf). No study has yet been carried out at this location for investigating traces of ancient mining.

An enormous increase in the amount of metal production and rapid developments in metal production technologies are observed in Anatolia following 2800 BC, for which Yalçın (2013) has coined the term "Industrial Phase". Because the sulphurous polymetallic ores mined from underground galleries cause much air pollution during the roasting and smelting stages of ore processing, in this period, smelting was carried out at workshop areas close to the mines, rather than at urban and residential sites.

Slag heaps near mine deposits at Keban and Ergani bear witness to the intensive metallurgical activities of this period (Seeliger *et al.* 1985). Moreover, the settlements inhabited by mineworking communities nearby ancient mines and smelting sites started to involve in intensive and complicated operations for mining and smelting of ores in the Early Bronze Age, as exemplified by the case of Derekutuğun (Yalçın 2019) and Göltepe mining village (Adriaens *et al.* 1996). Creating a cooperative model in metal production and networking multiple smelting sites maintained the minimalization of the uncertainty to access raw materials (i.e., ingots) (Lehner and Yener 2014: 548). As a result of this temporal change in the organization of metallurgical activities, finds recovered from settlement sites of this period are mostly limited to crucibles, moulds, ingots, finished or semi-finished metal products, while slag from on-site smelting as encountered in earlier phases, is absent.

Along parallel lines with the patterned distribution of finds in the 'industrial phase' in Anatolian metallurgy, archaeological evidence from Murat Höyük shows that only secondary production activities (casting and forming) were carried out on site. Likewise, at Arslantepe, where casting crucibles similar to the one from Murat Höyük were unearthed, metallurgical evidence from Early Bronze Age III levels are restricted to casting and forming stages of production; and in contrast to the earlier periods, there is no evidence for on-site smelting (Di Nocera *et al.* 2004: 125). The same situation is valid for Early Bronze Age IIIB/C phases at Norşuntepe (Pernicka *et al.* 2002: 130-131). Therefore, we may postulate that, semi-formed products, i.e., ingots, brought to Murat Höyük were melted in crucibles in the hearths set up in the courtyard area in grid square T19. Forming process involved pouring the copper melt into moulds made of stone or clay. After this stage, if necessary, heat-treatment and mechanical forming by hammering and scraping followed these steps. Some of the fragments of two-piece moulds with rivet holes found at Murat Höyük can be identified as moulds for shaft-hole axes, which is a complex form that requires mastery of advanced metalworking techniques. The Murat Höyük crucible is large enough to be used for melting up to about 300 grams of copper-alloy in a single casting operation. Evidence from Norşuntepe also demonstrates that complex casting techniques were developed with the onset of Early Bronze Age IIB/C, replacing the older method that involved a simple mould for preforms, which were then forged into a finished product by hammering. Therefore, it seems plausible to suggest that the metalworkers of the EBA III community inhabiting Murat Höyük were influenced by the advances in metallurgy taking place in the Upper Euphrates Basin during the Early Bronze Age.

Although we have no direct evidence to indicate that the figurine and the perforator found in Phase IV at Murat Höyük were cast and shaped at the site, the crucible and moulds found in the same grid square constitute direct evidence for the production stages of metal objects of similar nature carried out on site. P-XRF analyses have shown that the tool and the figurine were shaped from metals procured from different ore sources. The metal used in casting the figurine contains a low amount of tin, which indicates that it was manufactured by smelting tin-bearing copper minerals. In other words, the low tin content of this artefact indicates that it is not an intentionally produced copper-alloy, i.e., bronze. Beginning with the Chalcolithic Period, copper objects containing low amounts of tin are encountered at many Anatolian settlements, which supports our findings. On the other hand, the ore from which the tool MH19-69 was produced probably consisted of chalcopyrite and galena. In the metal compositions of both objects, the presence of elements such as antimony, nickel, and cobalt, even if in low percentages, indicate that the ore sources were rich in minerals containing different elements, i.e., they were polymetallic ores. This finding is also paralleled in the region, as is reflected at Early Bronze Age IIIB/C Arslantepe, where the tendency to use metals from polymetallic ores has been noted (Di Nocera *et al.* 2004: 125). Similarly, during the analysis of Early Bronze Age metal weapons from Erzurum and Kars Museums, besides spearheads made from arsenical copper, pure copper tools were encountered (Işıklı and Altunkaynak 2014: 78). The analysis of a dagger from this group revealed nickel and antimony content up to 1% which is an indicator of the usage of polymetallic copper ores (Altunkaynak 2016: 213).

CONCLUSIONS

Salvage excavations and surveys conducted in Keban Dam reservoir area during 1968-1976 demonstrated that the Upper Euphrates Basin was inhabited by complex societies since early prehistory, contrary to the commonly held belief that the highlands of Eastern Anatolia were too hostile for early human settlements. Prior to the Keban Project, Near Eastern archaeologists perceived the region as a secondary settlement zone and a periphery of the great Mesopotamian 'core' civilisations (Özdoğan 2006: 14). The most significant result of Keban Project, a milestone in the history of Anatolian archaeology, was the discovery that the region was continuously inhabited since the Neolithic Period (Özdoğan 2006: 15). Thus, archaeological evidence led to the understanding that the Antitaurus range did not constitute a geographical barrier between Syria-Mesopotamia and Anatolia. Rather, and to the contrary, this crescentic belt across the modern provinces of Elazığ – Malatya – Bingöl was a lively hub of interactions between neighbouring cultural spheres, while distinct local traditions also developed in the region (Özdoğan 2019a: 45). Subsequently, salvage projects in Karakaya and Atatürk dam reservoirs provided new archaeological evidence to support these observations, changing the way the region is perceived in broader Near Eastern scholarship. As a whole, these regional projects demonstrated that communities inhabiting the settlement basins north of the Antitaurus range developed an independent, local cultural idiom, while integrating cultural traits from neighbouring communities in Syria-Mesopotamia (Özdoğan 2019b: xvi). Moreover, excavations and analytical studies revealed that they utilised the great advantage of the availability of metal resources and carried out complex metallurgical activities since prehistoric periods.

From an iconographic point of view, the metal figurine from Murat Höyük bears certain traits (e.g., standing pose, conical hat) with contemporaneous depictions of female nudes in neighbouring regions; however, its execution is local in style. Likewise, the anthropomorphic clay figurines from the same phase at Murat Höyük bear little resemblance to figurines from late EBA contexts in Anatolia and neighbouring regions. The idiosyncratic style of anthropomorphic depictions at the site may be regarded as the reflections of a local community culture that developed within a relatively closed interaction sphere. Given that the site lies in the eastern reaches of Eastern Anatolian highlands, we may imagine that the cultural interactions involved in the production, emulation, barter and gift-exchange of nonutilitarian objects would have remained at a local level, reaching as far as the Elazığ-Malatya region, but not beyond. In this period, Murat Höyük probably remained outside the cultural spheres connected by the lively inter-regional trade network that developed along the "Great Caravan Route" across inland Anatolia from Cilicia to Troia and the Aegean (Şahoğlu 2005; Efe 2007).

Nevertheless, as a result of its rich obsidian deposits, Bingöl region was connected with far-reaching obsidian exchange systems since early prehistory, which linked the region with cultural interaction spheres of the Upper Euphrates Basin. Material culture styles and technological developments in Bingöl area were influenced to a certain extent by developments taking place along the Euphrates across the periods. Murat Höyük Phase IV (EBA III) material culture remains consist of the characteristic Karaz (Kura-Araxes) wares of the period, as well as other elements frequently attested together with these wares: andirons, portable hearths, 'çeç'-type stamp-seals, anthropomorphic and zoomorphic figurines, weaving tools, and obsidian blades and arrowheads. Preliminary analysis of obsidian finds from Murat Höyük show that obsidian was procured from various sources in Bingöl area. Metal production at the site during this period shows influence from the Upper Euphrates Basin, which is reflected in the use of copper ingots smelted from polymetallic ores, the form of the crucible with vertical lug-extensions, and complex two-piece moulds for casting. The recovery of fragments from three separate moulds for shaft-hole axes from a single, communal courtyard context strongly implies that this community was specialised in the production and trade of metal objects.

Evidently, metalworking skills did not only serve utilitarian purposes at the site, as not only is the Murat Höyük copper figurine most definitely a ritual object, but it is highly likely that the shaft-hole axes produced at the site were also meant for ceremonial deposits. It is also worthy of attention that, unlike the great majority of anthropomorphic metal figurines from EBA sites, the Murat Höyük figurine does not come from a funerary or ritual deposit, nor is it adorned with precious metals or gems. Instead, this modest copper figurine was found in a courtyard that was shared by the community for various daily tasks. In this regard, the figurine is of great significance for shedding light on the communal symbolic life of an EBA village.

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