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Tipolojinin Ötesinde: Tralleis Batı Nekropolü Mezar Eşyalarının Taşınabilir XRF Spektrometrisi ile Bileşimsel Analizi

Arzu ÖZVER * Salih SOSLU**

Abstract: The archaeological study of necropoleis has traditionally relied on typological and stylistic analyses, often lacking comprehensive archaeometric investigations that could provide deeper insights into ancient material culture, production technologies, and socio-economic networks. This study addresses this methodological gap by presenting an interdisciplinary archaeometric investigation of grave goods excavated in 2017 from the Western Necropolis of the of Tralleis, located in the Kemer neighborhood of Efeler district, Aydın province. Despite the archaeological significance of Tralleis as a major Hellenistic and Roman urban center in western Anatolia, systematic scientific analyses of its necropolis assemblages have remained conspicuously absent from scholarly discourse. Employing portable X-ray Fluorescence (p-XRF) spectrometry, this research examines a representative corpus of funerary deposits recovered from chamber tombs, stone cist tombs, tile graves, pithos burials, and cremation urns. The analytical protocol encompasses both ceramic artifacts—including lamps, lykion vessels, situlae, jugs, and transport amphorae—and metal objects such as mirrors, bracelets, and rings. The p-XRF analyses yield critical data concerning compositional characteristics, clay provenance, firing technologies, and alloy compositions, thereby illuminating aspects of craft specialization, trade networks, and ritual practices. This investigation represents the first comprehensive archaeometric study of Tralleis necropolis material, transcending conventional descriptive approaches through the integration of advanced analytical methodologies. The findings contribute significantly to our understanding of mortuary practices, technological traditions, and regional exchange systems in ancient Caria during the Hellenistic and Roman periods.

Keywords: Tralleis, p-XRF Analysis, Necropolis Assemblages, Ceramic Archaeometry, Metallurgical Analysis

Öz: Nekropolis alanlarının arkeolojik incelemesi geleneksel olarak tipolojik ve stilistik analizlere dayanmakta, antik materyal kültürü, üretim teknolojileri ve sosyo-ekonomik ağlar hakkında daha derin içgörüler sağlayabilecek kapsamlı arkeometrik araştırmalardan yoksun kalmaktadır. Bu çalışma, Aydın ili Efeler ilçesi Kemer mahallesinde yer alan Tralleis'in Batı Nekropolis'inde 2017 yılında gerçekleştirilen kazılarda ele geçen mezar buluntularının disiplinlerarası arkeometrik incelemesini sunarak bu metodolojik boşluğu gidermeyi amaçlamaktadır. Tralleis'in Batı Anadolu'daki önemli bir Hellenistik ve Roma dönemi kent merkezi olmasına

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This publication was supported by AADU Scientific Research Project Unit and prepared withind the scope of Project N. REF-22004. All of the findings in this study are from the Tralleis Necropolis. While some of the findings question are taken from the project, some of them consist of finding obtained in necropolis excavations and introduced for the first time in this study. The archaeometric analysis of the findings.

karşın, nekropolis buluntularının sistematik bilimsel analizleri akademik literatürde belirgin biçimde eksik kalmıştır. Taşınabilir X-ışını Floresan (p-XRF) spektrometrisi kullanılarak yürütülen bu araştırma, oda mezarlar, taş sanduka mezarlar, kiremit mezarlar, pithos gömüler ve kremasyon urnelerinden çıkarılan temsili bir cenaze buluntuları korpusunu incelemektedir. Analitik protokol, kandiller, lykion kapları, situlalar, testiler ve ticari amphoralar gibi seramik eserlerin yanı sıra aynalar, bilezikler ve yüzükler gibi metal nesneleri de kapsamaktadır. p-XRF analizleri, bileşimsel özellikler, kil kökeni, pişirme teknolojileri ve alaşım kompozisyonları hakkında kritik veriler sunarak zanaat uzmanlaşması, ticaret ağları ve ritüel uygulamaların çeşitli yönlerini aydınlatmaktadır. Bu araştırma, Tralleis nekropolis malzemesinin ilk kapsamlı arkeometrik çalışmasını temsil etmekte ve ileri analitik metodolojilerin entegrasyonu yoluyla geleneksel betimleyici yaklaşımları aşmaktadır. Bulgular, Hellenistik ve Roma dönemlerinde antik Karia Bölgesi'ndeki ölü gömme pratikleri, teknolojik gelenekler ve bölgesel değişim sistemlerinin anlaşılmasına önemli katkılar sağlamaktadır.

Anahtar Kelimeler: Tralleis, p-XRF Analiz, Nekropol Buluntu Toplulukları, Seramik Arkeometrisi, Metalürjik Analiz

Introduction

Tralleis is in the Topyatağı region, north of the Kemer district, in the center of modern Aydın. The knowledge of the early history of the ancient city of Tralleis is limited. Historically, it was adjacent to Thyeira / Thyaira / Tire and Lydia to the north, Ephesus to the northwest, Magnesia and Maeandrum to the southwest, as well as the territory of Ionia[1]. The excavations conducted on the site[2] have revealed several architectural remnants and archaeological artifacts that illustrate the city's artistic heritage. Recent excavations and studies in the city, alongside surviving textual sources, have revealed that it was a significant production center throughout the Roman period, particularly through pottery[3] and glass[4] artifacts. The conducted investigations demonstrate that the city was a production center of "Eastern Sigillata B" throughout the Roman period, with Pliny the Elder's accounts corroborating this statement[5].

Research conducted to date indicates that the Tralleis necropolis spans a considerable expanse in four directions and comprises at least four distinct necropolis sections within the city[6]. Data from the East, West, North and South necropolises, situated beneath the contemporary city of Aydın, indicates that the Tralleis necropolis is not positioned on a level terrain but extends towards hills

1 Özver 2021, 9.

2 For excavations and research carried out in the city, see: Leake 1824, 247; Chandler 1825, 260; Fellows 1852, 242; Texier 1862, 280; Rayet & Thomas 1877; Frothingham 1888, 486; Humann & Doerpfeld 1893, 395, Taf. XII-XIII; Edhem Bey 1904, 55; Dinç 1998, 205; Dinç & Dede 2003a, 11; Dinç & Dede 2003b, 405; Dinç & Dede 2004, 339; Yaylalı 2008, 551; Yaylalı 2009, 17; Yaylalı 2010, 375; Akkan, Saraçoğlu & Özver 2016, 265; Akkan & Saraçoğlu 2018, 367; Akkan, Öztürk & Karaosmanoğlu 2019, 173; Öztürk, Kavaz-Kındığılı & Güloğlu 2020, 559; Öztürk, Güloğlu, Özcihan & Toy 2022, 435. The excavations started in 2022 and are currently ongoing under the direction of the Aydın Museum, with scientific guidance by Prof. Dr. Murat Çekilmez from Aydın Adnan Menderes University.

3 Ölmez 2000; Civelek 2001; Baylan 2008; Erol 2004; Takaoğlu 2006, 263-267; Erön 2013; Özver 2021; Coşkun 2022; Civelek 2010, 169-191; Saraçoğlu 2013, 475-495; Ertuğrul 2023.

4 Yaylalı 2008, 24-27; Erön 2015, 30.

5 Plin. *Nat*. 35, 46, 160-161. J. W. Hayes (2008, 31) corroborates this information, indicating that the city of Tralleis was included in Pliny the Elder's catalog of regarded production centers for "Eastern Sigillata B". He notes that the city's designation during the Augustan era was "Caesarea" a name imprinted on certain vessels, and that artifacts of high-quality Tralleis pottery from the early periods were discovered in Ephesus, a major trading center of the region. Hayes.

6 Özver 2021, 43.

and steep inclines[7]. The Tralleis necropolises, when evaluated together regarding their position, reveal that the tombs were constructed beyond the city limits in topographically favorable places[8].

Various types of tombs with distinct architectural characteristics have been discovered in the Tralleis necropolis, including chambers, cist graves, terracotta sarcophagi, pithoi, jars, amphoras, roof tiles, situlas, urns, simple earthenware tombs and platform tombs[9]. From the Hellenistic to Eastern Roman periods, these tombs reflect burial custom and regional contacts, seen in both burial goods and architectural design[10].

The western necropolis of the city, where the materials pertinent to this study were discovered, is situated to the north of the inclined valley and beyond the city walls, commencing from the slope on the western periphery of the city and partially adjacent to the modern asphalt road that connects the Kemer district to the area commonly referred to as Üçgözler[11]. The initial research conducted in the western necropolis of Tralleis was a salvage excavation by the Aydın Archaeological Museum. Subsequently, excavations were conducted in this region from 2007 to 2008 under the supervision of Prof. Dr. A. Yaylalı, a faculty member of the Archaeology Department at Adnan Menderes University[12]. A total of 40 graves, comprising nine distinct types, were excavated within a limited area. These included one two-storey and two-roomed chamber tomb with dromos, one arched and single-roomed chamber tomb, three stone cist graves, eight situlas, three amphorae, five urns, 16 roof tiles, one simple earthenware, two pithoi, and one platform type.

The discovery of chamber tombs and different types of multi-burial rooms, notable for their artifacts, distinguished the city for its funerary architecture and necropolis finds. The Tralleis West Necropolis found most of its artifacts within the graves, while trenches outside the tombs held a minority. Both inside and outside the tombs, these discoveries were thought to come from the same necropolis. Consequently, a detailed examination of the artifacts from the tombs at Tralleis revealed a substantial assemblage of materials exhibiting diverse forms, types, and styles[13].

This study focuses on the tombs and artifacts found in this area between 2007 and 2008. The materials analyzed in our research were gathered from the excavation of 39 tombs in 2007 and published in 2008[14]. The single-room chamber tomb discovered in the same vicinity in 2008 was introduced in 2009[15] and 2024[16]. The findings concluded that the western necropolis of Tralleis was utilized from the third quarter of the 4th century BCE until the end of the 4th century CE[17].

The coins, lamps, unguentariums, bowls, plates, single-handled jugs, amphorae, figurines, and unguentariums recovered from the tombs in the western necropolis of Tralleis were presumed to be grave goods, with the majority of the artifacts found in an intact condition. So, 13 terracotta artifacts found in the Tralleis excavation depot that were the lamps, lykions, urns, situlas and situla lids, single-handled jugs, and amphorae. Also, nine metal artifacts, such as mirrors, bracelets, and rings, were analyzed using p-XRF, which is a non-destructive technique.

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7 Özver 2021, 43.

8 Özver 2021, 42.

9 Özver 2021, 44.

10 Özver 2021, 45.

11 Özver 2021, 51-57.

12 Yaylalı 2008, 555-576; Yaylalı 2009, 17-40.

13 For detailed information on the Tralleis Western Necropolis and its finds, see: Özver 2021; Özver 2024, 107-132.

14 Saraçoğlu & Çekilmez 2008, 27-34.

15 Çekilmez 2009, 380-382.

16 Özver 2024, 107-132.

17 Özver 2021, 56.

Archaeometric analyses were conducted to identify the chemical composition of the tombs in the Western Necropolis of Tralleis, as well as the pottery and metal artifacts discovered therein, to elucidate the relationships among the samples and to evaluate their compositional similarities. The pottery and metal artifacts from the western necropolis of Tralleis were analyzed using the p-XRF technique, and the chemical properties of the materials were characterized. The presence of similarities in the chemical analysis.

A primary purpose is to compare and assess the results obtained from archaeometric analyses conducted and published[18] in past years on other artifacts from Tralleis. An effort has been undertaken to ascertain the clay composition and firing properties of the Tralleis terracotta artifacts. Furthermore, archaeometric analyses of metallic artifacts are quite uncommon. Consequently, there is a need for data that can be acquired through area research in addition to excavations. It is essential to identify the manufacturing technologies and resources of the Anatolian metal production centres and to correlate them with the excavation findings. The conducted investigations can yield insights into the identification and recording of artifacts, as well as the production technologies of various civilizations across different eras. p-XRF analysis has been employed to ascertain the metal elemental composition of the artifacts, provide comprehensive and general evaluations of the samples and establish alloy ratios.

Findings

Pottery and terracotta findings

Thirteen terracotta artifacts were discovered and examined in the necropolis region: Seven lamps (Fig. 1), an amphora grave, a single-handled jug, a lykion, two situlas and a situla lid (Fig. 2).

Lamps

A significant quantity of lamps was discovered in the tombs of the western necropolis of Tralleis. Seven of these lamps were chosen as samples and analyzed.

Lamp 1: A fragment of the nose and base of the “Ephesos type” lamp from trench I of the western necropolis of Tralleis has been conserved. It possesses a spear-shap nose, is substantial in size, features an oval wick hole, and is molded. The clay exhibits a reddish-yellow color (7.5 YR 7/ 8) and contains inclusions of mica, limestone, and sand. The lamp discovered in trench I has been dated to the late 2nd century BCE to the 1st century CE based on comparable artifacts[19].

Lamp 2: The handle and nose of the “Ephesos type” lamp discovered in the southern corner of kline 2 within the chamber tomb with dromos are damaged. The object features a round body, a double convex contour, a plastic band encircling the broad discus aperture, three tiny air vents adjacent to the oil opening, a relief vase pattern in the channel between the wick aperture and the discus, floral decorations on the shoulder, and a slightly elevated base. The body is micaceous, pinkish-grey (7.5 YR 7/2), while the interior is black (5 YR 2.5/1). Comparative analysis with similar objects[20] which are known as “Ephesos type” has dated to the late 2nd century BCE to the early 1st century BCE[21]. The object in question is believed to have originated at Ephesus, exhibiting the distinctive characteristics of Ephesian lamps, including air vents surrounding the disc, a doughy texture, grey clay, a dark grey-black metallic glaze, a spear-head nose, and floral designs on the shoulder[22].

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18 Takaoğlu 2006, 263-267; Doymaz 2021, 139-147; Ertuğrul 2023, 250-282; Avcı 2024, 145-160.

19 Özver 2021, 367, Cat. No: 31.

20 Howland 1958, No: 651, Pl. 49; Hayes 1980, 55, Pl. 7; Gürler 1994, 167, Pl. 35; Civelek 2001, Cat. No: 13, Pl. 7.

21 Özver 2021, 365, Cat. No: 25.

22 Özver 2021, 138.

Lamp 3: Another example of the "Ephesos type"[23] lamps from the chamber tomb was discovered in the southern section of kline 4. The handle and nose of this object, produced by using a mold, have not lasted. The object features a circular body, a double convex contour, an expansive oil aperture, a plastic band encircling the broad discus opening, and a rounded, slightly elevated base. The clay has a reddish-yellow hue (7.5 YR 7/8) with the incorporation of mica, lime, and sand, while the coating is red (10 R 4/6). The "Ephesos type" lamp from the chamber tomb has been dated to the late 2nd to early 1rd century BCE based on the tomb context and other objects[24].

Lamp 4: A portion of the discus and the complete handle are absent from the lamp with lug discovered at the base of the chamber tomb with dromos. The object is shaP with an oval nose, a concave disc, a plain shoulder featuring an outwards protruding ear and a circular, flat base. The somewhat damaged and unadorned disc is encircled by three rings. The clay exhibits a reddish-yellow color (5 YR 6/6) with little specks of mica, lime, and sand, while the lining is red (2.5 YR 4/6). Based on comparable examples[25], the lamp with lug is dated to the first half of the 1st century CE[26].

Lamp 5: An additional instance of "Ephesos type" lamp was discovered in roof tile tomb 12. The handle and right flange are damaged. Moulded, rounded snout and body, unembellished, narrow, round, concave disc featuring a small oil aperture at the center, left shoulder exhibiting an outwardly extending flange, slightly concave round base, the disc delineated by concentric circles, elongated nose bridge adorned with a beardless mask figure linked to the disc perimeter, and a fruit ivy motifs on the shoulder. The clay is pink (5 YR 7/4) containing mica, lime, and sand, whereas the lining is crimson (10 R 5/6). The "Ephesos type" lamp discovered in roof tile tomb 12 is dated to the late 2nd century BCE to the early 1st century BCE[27] based on similar artifacts[28].

Lamp 6: The lamp from the vaulted chamber tomb of the western necropolis of Tralleis is complete, with the exception of its fractured nose. It is shap, including a round body, broad and sloping shoulders, a ridged vertical handle, a circular base and a large concave disc. Two rectangular relief panels are positioned on the shoulder of the lamp, opposing one another, while the discus features a mythical depiction[29] encircled by an interlocking ring. The clay exhibits a light red color (2.5 YR 7/6) containing mica and sand, while the lining is characterized by a white color (5 YR 8/1). This lamp, is dated to the 2nd-3rd century CE[30].

Lamp 7: Another example of lamps in the vaulted chamber tomb is a "Heart-Shap Nozzle" lamp. A molded, heart-shap nozzle, round body features a concave disc encircled by two intertwined relief circles, wide oil apertures, and a grooved vertical handle ascending from the disc. The round bottom displays a bust-shap figure of Tyche (?) adorned with a radiate crown on the disc's front, accompanied by an oil hole adjacent to the figure's left shoulder. The clay reveals a reddish-yellow color (5 YR 6/6) with the incorporation of mica, lime and sand, while the lining is characterized by a light red color (2.5 YR 6/8). The "Heart-Shap Nozzle" lamp in the vaulted chamber tomb is dated to the 1st-2nd century CE based on the tomb's context[31].

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23 Wiegand & Schrader 1904, 174 Pl. 558; Bruneau 1965, No: 2235, 2252, 2272, 2344, Pl. 12, Kassab-Tezgör & Sezer 1995, 117, No: 305; Ölmez 2000, Cat. No: 51, Pl. XLVII, Civelek 2001, Cat. No: 13, Pl. 7.

24 Özver 2021, 365, Cat. No: 28.

25 Brants 1913, 42, No: 726, Pl. V; Heimerl 2001, 116, No: 238, Pl. 6.

26 Özver 2021, 374, Cat. No: 46.

27 Özver 2021, 368, Cat. No: 33.

28 Bailey 1975, 202-203, Q 474, Pl. 89; Barın 1995, 11, Cat. No: 7, Pl. 3b; Kassap-Tezgör & Sezer 1995, 124, No: 333-334; Günay-Tuluk 1996, Cat. No: 38, Pl. 7a; Civelek 2001, 86, Cat. No: 77, Pl. 14; Okunak 2005, 89, Cat. No: 21.

29 Bailey 1980, 349, Q 1341; Heimerl 2001, 176, No: 992, Pl. 121.

30 Özver 2024, 124, Cat. No: 16.

31 Özver 2024, 121, Cat. No: 1.

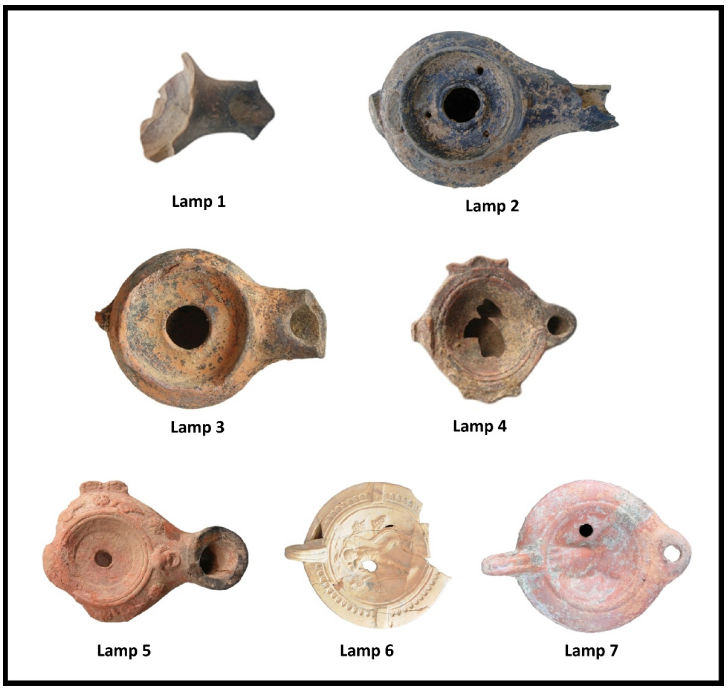

Fig. 1. Lamp 1-7

Amphora: In the 2007 excavations at the necropolis of Tralleis West, an amphora was discovered featuring a high rim, a long cylindrical neck, double handles, a pronounced shoulder transition and a broad body tapering towards the base, which was fractured along with the entire base. The coating is a light red (2.5 YR 7/6) with minimal mica and grit, whereas the lining is a white (5 YR 8/1). The amphora grave, devoid of grave items, has been dated to the Roman Imperial period according to its excavation level[32].

Jug: This jug was discovered in the western necropolis of Tralleis, within roof tile tomb 8. The Tralleis sample features a narrow, thickened rim, a wide cylindrical neck, a spherical body, a singular vertical handle with an oval cross-section linking the neck to the body, and a low ring base. Parallel grooves are present on the neck and body. The body is pink (7.5 YR 7/4) with a minimal quantity of mica, and the lining is similarly pink (5 YR 7/4). Comparative analysis of analogous artifacts[33] dates the single-handled jug to the 4th century CE[34].

Cream / Cosmetic / Pharmaceutical Jar (Lykion / Lycium?): A lykion was discovered in kline 2 of the chamber tomb with dromos located in the western necropolis of Tralleis. It features a broad, thickened rim, a short concave neck, a biconical body, a low foot, and a flat base. The coating is a pale crimson (10 R 6/4) including inclusions of mica, lime, and sand. It possesses an identical slip color to the clay. The Lykion discovery was dated to the latter part of the 2nd century BCE[35] based on the grave context and comparable artifacts[36].

Situla

Two situlae and one situla lid were analysed and evaluated in the study.

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32 Özver 2021, 358, Cat. No: 13.

33 Robinson 1959, M 227, Pl. 27; Vapur 2011, Cat. No: 41.

34 Özver 2021, 420, Cat. No: 138.

35 Özver 2021, 434, Cat. No: 167.

36 Sjöqvist 1960, No: 6, Pl. 20; Hershkovitz 1986, Fig. 2:3; Hayes 1991, No: 16, Fig. LVIII; Atik 1995, Fig. 21, 46; Işın 2002, 93; Özer & Doksanaltı 2017, 294.

Situla 1: It was discovered in trench 1 during the 2007 excavations in the western necropolis of Tralleis. It was retrieved in fragments and subsequently restored. It possesses a wide cylindrical form with an exteriorly thickened rim. Horizontal rows of grooves are present both inside and externally. The clay exhibits a bright red color (2.5 YR 7/6) and contains inclusions of mica, lime, and grit. The interior is the same color as clay. The situla grave[37], devoid of grave goods, was dated to the 1st century BCE - 1st century CE based on its excavation level[38].

Situla 2: The additional situla discovered in trench 1 was found in pieces and subsequently restored. The object possesses a wide cylindrical form featuring an exteriorly thickened rim. Horizontal rows of grooves are present on both the interior and exterior surfaces. The clay exhibits a light red color (2.5 YR 6/8) containing mica, lime, and grit inclusions, whereas the interior layer is a lighter shade of red (2.5 YR 7/6). The situla grave[39], devoid of grave objects, was dated to the 1st century BCE - 1st century CE, based on its excavation level[40].

Situla Lid: It was found in trench 1 is complete, with the exception of minor fractures. It possesses a round form and features a thick layer of chalk on its exterior. The clay exhibits a light red color (10 R 6/6) with inclusions of mica, lime and grit, while the lining is a light red shade (2.5 YR 7/2). The situla lid, associated with situla 1, is dated to the 1st century BCE to the 1st century CE[41].

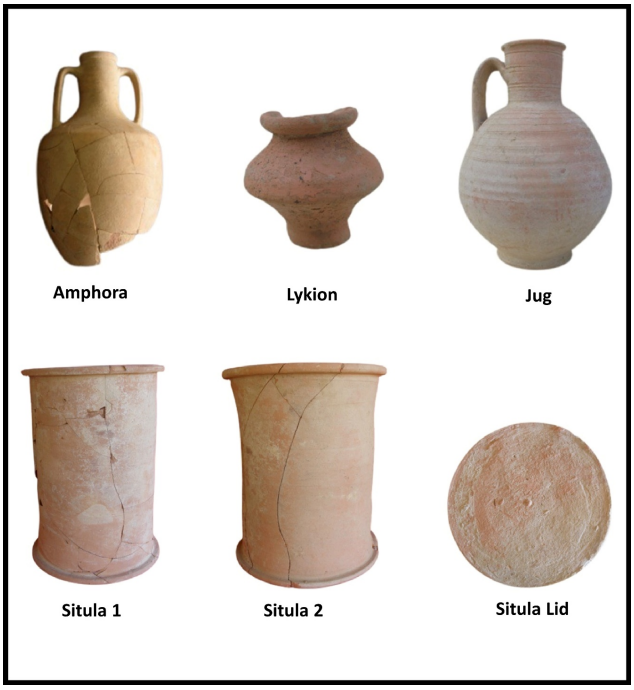

Fig. 2. Amphora, Lykion, Jug, Situla 1-2, Situla Lid

37 Özkan & Atukeren 1999, 1-55, Fig. 64 a-d; Şimşek 1999, 17, Fig. 39; Baysal 2000, 34, Fig. 17; Ürkmez 2002, 12; Şimşek 2002, 233; Yurtseven 2006, 93, 102, Fig. 1-2; Şimşek, Okunak & Bilgin 2011a, 12, Fig. 17, 29, 55, Fig. 48; Cat. No: 46; Baldoni 2019, 27, Fig. 11; Güllüsaç 2018, 54, Cat. No: 32, Fig. 23, 56, Cat. No: 41, Fig. 24, 57, Cat. No: 43, Fig. 26; Foça 2019, 81-82, 88, 91, 94, 96-97, Cat. No: 81-82, 88, 91, 94, 96-97.

38 Özver 2021, 352, Cat. No: 1.

39 Özkan & Atukeren 1999, 1-55; Fig. 64 a-d; Şimşek 1999, 17, Fig. 39; Baysal 2000, 34, Fig. 17; Ürkmez 2002, 12; Şimşek 2002, 233; Yurtseven 2006, 93, 102, Fig. 1-2; Şimşek, Okunak & Bilgin 2011a, 12, Fig. 17, 29, 55, Fig. 48; Cat. No: 46; Baldoni 2019, 27, Fig. 11; Güllüsaç 2018, 54, Cat. No: 32, Fig. 23, 56, Cat. No: 41, Fig. 24, 57, Cat. No: 43, Fig. 26; Foça 2019, 81-82, 88, 91, 94, 96-97, Cat. No: 81-82, 88, 91, 94, 96-97.

40 Özver 2021, 353, Cat. No: 4.

41 Özver 2021, 352, Cat. No: 2.

Metal Artifacts

A significant quantity of metal artifacts, predominantly composed of bronze, was discovered in the western necropolis of Tralleis. The metal artifacts examined in this study include a bracelet, a ring and seven mirrors (Fig. 3).

Bracelet: A bronze bracelet in the form of a simple ring was discovered in roof tile tomb 14 within the western necropolis of Tralleis. The Tralleis example was attributed to the reign of Constantius II (AD 337-361) based on analogous examples and coins found in the tomb[42].

Ring: The bronze ring examined for the first time in this paper was discovered intact in the southern corner of Kline 4 within the chamber tomb with dromos. The bronze ring, crafted from a singular piece, possesses a round form. The upper section of the ring is oval-shap with a flat surface. The undecorated ring has been dated to the Roman Imperial Period based on the tomb's context.

Mirrors

Seven bronze mirrors were found during the 2007 excavations in the Tralleis Western Necropolis area.

Mirror 1: This mirror[43] was discovered undamaged in the southern corner of Kline 4 within the chamber tomb with dromos. The surface of the bronze mirror, shap as a narrow rectangular plate devoid of a handle is oxidized. The bronze mirror from Tralleis has been chronologically assigned to the Roman Imperial period based on its burial context and analogous artifacts[44].

Mirror 2: The bronze mirror, previously unexamined, was discovered in the center of kline 4 within the chamber tomb with dromos. The surface of the bronze mirror, shaP as a thin circular plate, is oxidized. The bronze mirror was dated to the Roman Imperial Period based on the context of the tomb and analogous examples.

Mirror 3: The edges of a third bronze mirror[45] discovered in trench 1 are damaged. The surface of the bronze mirror, a singular thin circular plate with a little concavity, is oxidized. The bronze mirror from trench 1 was dated to the Roman Imperial Period through research and comparison[46].

Mirror 4: The bronze mirror examined in our study was identified as a partial bronze mirror located in the chamber tomb with dromos within Kline 5. The mirror, characterized as a slender circular plate encircled by a sequence of perforated dots borders, is attributed to the Roman Imperial Period based on its surroundings and similar artifacts.

Mirror 5: It was discovered in two fragments in the southeastern section of Kline 4 within the chamber tomb with dromos. The surface of the bronze mirror[47], characterized by a thin, circular, slightly concave plate, is oxidized. The discovery from the chamber tomb is attributed to the Roman Imperial Period based on the tomb's surroundings and related examples[48].

Mirror 6: This previously unpublished mirror was discovered in a fragmented condition in Kline 2 within the chamber tomb with dromos. The surface of the bronze mirror, shap as a thin rectangular

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42 Özver 2021, 537, Cat. No: 374.

43 Özver 2021, 539, Cat. No: 380.

44 Şahin 2010, Cat. No: B 35-B 36-B 37; Şimsek, Okunak & Bilgin, 2011 b, 674, Cat. No: 664; Çelikbaş 2016, 323, Cat. No: E 17.

45 Özver 2021, 539, Cat. No: 378.

46 McFadden 1946, Pl. XLVII/131-133; Boulter 1963, T 3; Gürler 2004, Cat. No: 35; Çelikbaş 2016, 314-318, Cat. No: E3, E5, E7-9; Şimsek, Okunak & Bilgin, 2011 b, 482, 526, 533, Cat. No: 306, 394, 416.

47 Özver 2021, 539, Cat. No: 379.

48 McFadden 1946, Pl. XLVII/131-133; Boulter 1963, T 3; Gürler 2004, Cat. No: 35; Çelikbaş 2016, Cat. No: E3, E5, E7, E8, E9; Şimsek, Okunak & Bilgin, 2011 b: Cat. No: 306, 394, 416.

plate, is oxidized. The bronze mirror from the Tralleis discovery is attributed to the Roman Imperial Period based on the tomb surroundings and similar artifacts.

Mirror 7: The mirror, previously unexamined in any study and the focus of this paper, has been recovered from trench 1 and exhibits cracks around the edge of the bronze surface. The surface of the bronze mirror, a singular, circular, thin plate with a tiny concavity, is oxidized. Based on analogous instances, the bronze mirror discovered in trench 1 was dated to the Roman Imperial Period.

Fig. 3. Mirror 1-7, Bracelet, Ring

Archaeometric Analysis of the Artifacts

Materials and Methods

Pottery and metal artifacts from the excavation of the Tralleis during the 2007 and 2008 seasons have been subjected to archaeometric analysis. The initial analysis group comprised seven lamps, amphoras, lykions, jugs, situlas (1-2), and situla lids, whereas the subsequent analysis group consisted of seven mirrors, bracelets, and rings. A total of 22 pottery and metal artifacts were analyzed.

The studies were conducted using non-destructive procedures, as the removal of components from the artefacts and the use of destructive techniques were prohibited. Nonetheless, a study on analytical methods indicated that the rays from the p-XRF (X-ray fluorescence) examination could potentially harm the artifact, resulting to potentially misleading results[49]. The reason for choosing p-XRF analysis is that it is an in situ and non-destructive analysis method. The chemical compositions of the pottery and metal artifacts in research were analyzed using the p-XRF method[50] with the Spectro/xSort XH003 equipment. The p-XRF approach was selected due to its attributes, including sensitivity to ppm (part per million) in non-destructive artefact examination, surface measurement

49 Pearce 2018, 81-85.

50 Shackley 2011.

capability and chemical component determination. The spectrometer possesses an energy of 40 eV[51]. The analysis duration was established as 40-60 seconds. p-XRF analysis elucidated and quantified the chemical constituents and alloys of the objects. Data was acquired by analyzing several aspects of a singular study.

Results of Analysis

Examination of Pottery and Terracotta Artifacts (Lamp, Amphora, Lykion, Jug, Situla, and Situla Lid)

The mean elemental composition of the pottery samples is as follows: 53.4% SiO_2 (Silicon dioxide), 19.8% Al_2O_3 (Aluminum oxide), 9.2% ZrO_2 (Zirconium), 6% Fe_2O_3 (Iron oxide), 4.4% CaO (Calcium oxide), 4.4% P_2O_5 (Diphosphorus pentoxide), 3.8% K_2O (Potassium oxide), and 1.2% TiO_2 (Titanium dioxide), (Fig. 4).

No	Element	Type Conc.	Lamp 1	Lamp 2	Lamp 3	Lamp 4	Lamp 5	Lamp 6	Lamp 7	Ort.
1	Al_2O_3	%	11,812	15,240	20,509	16,321	13,144	16,991	28,114	19,8
2	SiO_2	%	63,309	40,209	51,773	49,938	49,243	61,929	47,615	53,4
3	P_2O_5	%	0,082	11,814	6,433	3,743	3,392	1,321	1,177	4,4
4	K_2O	%	3,047	4,147	3,300	3,104	7,363	0,352	2,769	3,8
5	CaO	%	6,613	6,205	2,082	6,057	0,710	2,729	1,404	4,4
6	TiO_2	%	1,144	0,698	0,870	0,591	0,021	5,144	0,753	1,2
7	MnO	%	0,116	0,067	0,105	0,092	0,140	0,120	0,021	0,094
8	Fe_2O_3	%	7,559	3,028	5,577	3,742	7,783	6,565	8,033	6
9	NiO	%	0,045	0,023	0,019	0,041	0,027	0,023	0,013	0,027
10	CuO	%	0,007	0,054	0,012	0,006	0,007	0,006	0,010	0,014
11	ZnO	%	0,014	0,035	0,018	0,017	0,014	0,010	0,018	0,018
12	Rb_2O	%	0,013	0,005	0,011	0,011	0,002	0,011	0,012	0,009
13	SrO	%	0,021	0,047	0,030	0,032	0,015	0,019	0,017	0,025
14	Y	%	0,003	0,015	0,002	0,002	0,004	0,002	0,004	0,005
15	ZrO_2	%	6,110	20,410	5,250	7,690	9,940	5,690	2,890	9,2
16	Nb_2O_5	%	0,002	0,010	0,001	0,002	0,003	0,002	0,002	0,003
17	BaO	%	0,179	0,014	0,097	0,042	0,079	0,055	0,046	0,073
18	PbO	%	0,016	0,033	0,121	0,015	0,002	0,003	0,009	0,028
19	Th	%	0,002	0,322	0,005	0,002	0,003	0,001	0,002	0,048

Fig. 4. Results of p-XRF analysis of lamp samples from Tralleis excavation

The average SiO_2 content of 53.4% may be directly related to the hard clay composition of the pottery or may be due to quartz minerals in the ceramic. It may also have come from the gneiss rocks of the region. When the element combines with various components, it produces a hard structure similar to pottery. This structural property is also found in materials such as concrete, glass, porcelain and tiles, where the element is used. Therefore, gneiss, the regional material of Caria, clearly contributes to this development. The average Al_2O_3 content of 19.8% guarantees that the pottery exhibit exceptional resistance to corrosion and abrasion at elevated temperatures, while maintaining a robust structure. It imparted a vitreous luster to the pottery. A temperature of over 1000°C is generally required for the formation of this component. Mica contribution was also identified. The average concentration of Fe_2O_3 at 6% enhanced the colours of the pottery and imparted vibrancy. The average CaO content of 4.4% indicates that the pieces of pottery contain a clay with lime additions. The average SrO content in pottery is rather low and geochemically

[51] Potts and West 2008; Liritzis and Zacharias 2011.

analogous to CaO. Due to the presence of elements like seashells and limestone. The average SrO concentration of 0.025%, which is low, suggests that most raw materials utilized in pottery production are not of coastal origin. The average ZrO_2 content of 9.2% indicates the extensive utilization of terrestrial raw resources in pottery formulations. In this context, considering the average SrO and ZrO_2 in pottery production, it is evident that the contribution rate of terrestrial raw materials surpasses that of coastal raw materials. The variations in the ratios of aluminum oxide (Al_2O_3) and silicon dioxide (SiO_2) in pottery provide a significant indicator about the source of raw materials. The predominance of trace elements in comparable ratios is attributable to the geological composition of the ancient city and its vicinity.

The mean concentrations of the principal elements in the samples are as follows: SiO_2 (silicon dioxide) at 58.9%; Al_2O_3 (aluminium oxide) at 21.6%; Fe_2O_3 (iron oxide) at 7.3%; CaO (calcium oxide) at 5.448%; K_2O (potassium oxide) at 2.874%; and P_2O_5 (diphosphorus pentoxide) at 1.045% (Fig. 5).

No	Element	Type Conc.	Amphora	Lykion	Testi	Situla 1	Situla 2	Situla Kapağı	Ort.
1	Al_2O_3	%	8,299	23,023	24,248	26,473	24,6	23,954	21,6
2	SiO_2	%	64,457	63,996	56,923	56,058	56,8	58,586	58,9
3	P_2O_5	%	0,233	0,397	6,433	0,089	0,098	0,164	1,045
4	K_2O	%	3,089	3,666	3,563	2,778	4,49	3,536	2.874
5	CaO	%	14,244	1,603	4,274	8,057	6,33	4,628	5,448
6	TiO_2	%	2,294	0,739	0,766	0,591	0,78	0,920	0,727
7	MnO	%	0,152	0,086	0,116	0,092	0,1	0,079	0,089
8	Fe_2O_3	%	8,119	7,744	6,577	6,742	8,42	9,437	7,3
9	NiO	%	0,023	0,016	0,038	0,041	0,044	0,039	0,028
10	CuO	%	0,008	0,005	0,005	0,006	0,006	0,008	0,005
11	ZnO	%	0,009	0,014	0,013	0,017	0,014	0,015	0,006
12	Rb_2O	%	0,009	0,011	0,013	0,011	0,013	0,014	0,010
13	SrO	%	0,027	0,016	0,026	0,032	0,027	0,023	0,021
14	Y	%	0,002	0,002	0,004	0,002	0,003	0,003	0,005
15	ZrO_2	%	0,019	0,016	0,017	0,025	0,018	0,025	0,017
16	Nb_2O_5	%	0,001	0,001	0,002	0,003	0,002	0,003	0,002
17	BaO	%	0,291	0,187	0,125	0,188	0,12	0,055	0,138
18	PbO	%	0,016	0,007	0,001	0,015	0,001	0,001	0,005
19	Th	%	0,001	0,002	0,002	0,003	0,002	0,002	0,001

Fig. 5. Results of p-XRF analysis of amphora, lykion, jug, situla (1-2) and situla lid samples from the Tralleis excavation

The average SiO_2 content of 58.9% indicates that the samples possess a hard clay structure. It is possible to say that the gneiss and quartz minerals, which are the rock structure of the region, are effective in the formation of this situation. The average Al_2O_3 content of 21.6% indicates that the samples consist of a raw material with significant abrasion resistance. A temperature of no less than 1000 °C is necessary for the formation of this component, and the clay of the samples exhibits this property as well. Mica was additionally discovered in the clay. The local gneiss of the Caria region demonstrated an efficacy with an average SiO_2 content of 58.9%. The average CaO content of 5.448% indicates that the potteries contain a lime-enriched mixture. The typical SrO content in the pottery is rather low and geochemically analogous to CaO. The low average of SrO at 0.021% suggests that the majority of raw materials utilized in the fabrication of the samples were not of coastal origin; the average of ZrO_2 at 0.017% shows that terrestrial source materials were not extensively incorporated into the sample clay. The K_2O average of 2.874% signifies that potassium oxide was utilized in a quantity that inhibited the facile breakdown of the clay in the samples.

Studies conducting archaeometric examinations of pottery and terracotta figurines in Tralleis are evident, and although limited in quantity, they yield significant data pertinent to our study. The initial research is titled “New Light on the Origins of Eastern Sigillata B Ware”. The study of the pottery revealed that Al_2O_3 ranged from 13.62% to 16.11%, K_2O from 3.10% to 4.37%, and CaO from 1.06% to 8.21%[52]. The second study is titled “Roman Ceramics Discovered in Tralleis from 1996 to 2005”. The examination of the clay in the Tralleis pottery revealed that Al_2O_3 ranged from 13.74% to 15.85%, K_2O ranged from 3.35% to 4.23%, and CaO ranged from 4.75% to 8.99%[53]. The third study is named “Terracotta Figurines from Aydın Archaeological Museum”. The examination of the figurines from Caria and Tralleis revealed that Al_2O_3 constitutes 17.55%, K_2O comprises 2.60%, and CaO accounts for 2.09%[54]. The fourth study is titled “Archaeometric Investigation of a Group of Terracotta Figurines from the Tralleis Find”. The studies of this study revealed that Al_2O_3 constituted 19.92%, K_2O included 3.6%, and CaO accounted for 5.6%[55]. The analyses conducted on the Tralleis findings indicate that the results for Al_2O_3 (aluminium oxide), K_2O (potassium oxide), and CaO (calcium oxide) are closely aligned. In the analysis of the lamp group, the composition was as follows: Al_2O_3 at 19.8%, K_2O at 3.8%, and CaO at 4.4%. In contrast, the analysis of other terracotta artefacts (amphora, lykion, jug, situla, and situla lid) revealed Al_2O_3 at 21.6%, K_2O at 2.874%, and CaO at 5.448%. Upon reviewing the aforementioned Tralleis data, it is evident that the proportions of clay components are essentially comparable. Gneissic and micaceous minerals were present in all constituents. The SiO_2 ratio in the investigated items varied from 53.4% to 58.9%, a finding closely associated with the results of the analytical investigations conducted on the artefacts in the city. This element, a compound of silicon and oxygen, is the most prevalent in nature and manifests as sand, quartz, amethyst, and citrine. This element is linked to gneiss, a metamorphic rock. This stone is the indigenous stone of the Caria. The presence of chemicals like CuO, ZnO, NiO, MnO, BaO, PbO, SrO, and ZrO_2 in the artefacts indicates chemical oxidations inside their structure, corroborating findings from other investigations conducted in the city. The compound Fe_2O_3 varies between 6% and 7.3% and is the iron oxide responsible for the red color in glaze. It also features blue, yellow, purple, green, and orange colors; nonetheless, analyses indicate that it imparts a red coloration to the terracotta artifacts. In this context, based on prior examinations of the Tralleis artefacts and the findings from our study's artefact analyses, it has been established that the chemical elements exhibit comparable values.

Examination of Metal Artifacts (Mirrors, Bracelets and Rings)

All investigated objects were ornamental items, with the first group being mirrors and the second group consisting of personal jewellery, including bracelets and rings. The p-XRF technique was employed to ascertain the alloy and chemical constituents. The objects contained the elements Sn (tin), Ni (nickel), Si (silicon), P (phosphorus), Co (cobalt), As (arsenic), Cu (copper), Sc (scandium), Zn (zinc), Pb (lead), Fe (iron), Rh (rhodium), S (sulphur), Ga (gallium), Sb (antimony), and Cr (chromium), (Fig. 6).

52 Takaoğlu 2006, 270.

53 Ertuğrul 2023, 279.

54 Doymaz 2021, 139-147.

55 Avcı 2024, 149-151, 158.

No	Element	Type Conc.	Ayna 1	Ayna 2	Ayna 3	Ayna 4	Ayna 5	Ayna 6	Ayna 7	Bilezik	Yüzük
1	Sn	%	0,86	13,98	8,75	8,22	10,23	11,60	29,48	-	-
2	Ni	%	0,021	0,062	0,022	0,027	0,028	0,030	0,046	0,071	0,047
3	Si	%	0,98	15,61	8,24	0,29	0,80	0,65	2,70	5,11	1,33
4	P	%	15,44	10,74	0,51	12,17	1,31	7,25	1,13	1,64	11,79
5	Co	%	0,014	0,034	0,070	0,020	0,035	0,033	-	-	0,006
6	As	%	0,11	-	0,17	0,079	0,16	-	0,089	0,53	0,22
7	Cu	%	82,5	58,9	79,8	72,6	87	64,7	58,5	78,9	86,2
8	Sc	%	0,12	-	-	-	-	-	-	-	0,098
9	Zn	%	-	0,028	-	-	-	-	0,14	13,19	-
10	Pb	%	-	15,61	2,10	6,53	-	15,57	7,59	-	-
11	Fe	%	-	0,42	0,24	0,019	0,31	0,077	0,031	0,36	0,018
12	Rh	%	-	-	0,079	-	-	-	0,13	-	-
13	S	%	-	-	-	-	0,10	-	-	0,20	0,28
14	Ga	%	-	-	-	-	0,005	-	-	-	-
15	Sb	%	-	-	-	-	-	0,090	0,12	-	-
16	Cr	%	-	-	-	-	-	-	0,091	-	-

Fig. 6. Metal artifacts; p-XRF analysis results of mirror (1-7), bracelet and ring samples

The primary element is copper. The mean copper concentration is 74.34%. The trace elements include nickel, cobalt, arsenic, scandium, iron, rhodium, sulfur, gallium, antimony, and chromium. These elements cannot be generated in adequate amounts to be ascribed to the producer's activity throughout the production phase. They may also be generated through mechanical cleaning. Iron is present in all factories except Mirror 1 and has been identified as a trace element. It is presumed that iron exists solely as an impurity or possibly due to corrosion. Upon examination of the tin and copper ratios in the artefacts, it was determined that either the copper artefacts (bracelets and rings) contained no tin, with a decreasing tin ratio corresponding to an increasing copper ratio, or a decreasing copper ratio was associated with an increasing tin ratio. Mirrors 2, 3, 4, 6, and 7 had lead in concentrations of 15.61%, 2.10%, 6.53%, 15.57%, and 7.59%, respectively. Research into ancient metallurgical technologies revealed that lead was predominantly utilized for casting and assembling intricate forms. Upon examination of the mentioned artefacts, it was determined that they lacked intricate design and were characterized by simplistic craftsmanship and design. Consequently, it is believed that the alloy's weight facilitated the incorporation of lead as an additive in the artifacts in issue; specifically, the copper artifacts were lightweight and increased by the addition of lead. In mirrors 2, 3, 4, 6, and 7 of the artifacts, tin and lead were utilized in conjunction with copper. The combination of these two elements with copper is a significant characteristic of Roman and Eastern Roman bronze artifacts[56]. In all operations, copper is utilized in conjunction with phosphorous. This is the most often utilized deoxidized copper. In addition, it was determined that the phosphorus rate was high with an average of 7.3%. This is thought to be due to contamination in metal artifacts.

Evaluation and Conclusion

The study analyzed two group of archeological findings. The initial group comprised seven lamps, amphoras, lykions, jugs, situlas (1-2), and situla lids, whilst the following group had seven mirrors, bracelets, and rings. Lamps 1-7 are dated to the 2nd century BCE - 3rd century CE. Except for Lamps 4, 6 and 7, they are determined as "Ephesos type". Lamp 7 is of the "Heart-ShaP Nozzle" type. Also, amphroa (Roman Imperial Period), jug (4th century CE), situlus 1-2 (1st century BCE - 1st century CE), situla lid (1st century BCE - 1st century CE). Metal finds: bracelet (4th century CE), ring (Roman

[56] Facsády and Verebes 2009.

Imperial Period), mirror 1-7 (Roman Imperial Period).

The analysis of the lamp group, the focus of our study, revealed Al_2O_3 at 19.8%, K_2O at 3.8%, and CaO at 4.4%; conversely, the analysis of the other terracotta artefacts (amphoras, lykions, jugs, situlas, and situla lids) indicated Al_2O_3 at 21.6%, K_2O at 2.874%, and CaO at 5.448%. The outcomes proved to be analogous to the analytical findings from prior experiments conducted at Tralleis. The SiO_2 ratio in the artifacts ranged from 53.4% to 58.9%. This element, a combination of silicon and oxygen, is the most prevalent element in nature. This component is gneiss, a metamorphic rock, which is also the local rock of the Caria and Tralleis. The element Fe_2O_3 was identified in the artefacts in concentrations of 6% and 7.3%, contributing to the red color in the glaze. These data align with the analytical research previously conducted in Tralleis. In this perspective, the results of prior examinations of the Tralleis finds and the artifacts in our study indicate that the chemical elements had comparable levels. It is not possible to claim that the studied terracotta artifacts were definitely produced in the same production center in Tralleis. More data and analysis are needed for this. However, it is possible to say that the analysis data in the studies on Tralleis mentioned in the text are similar. It can easily be said that they have comparable values. Also, analysis found a high phosphorus content. It is not certain, but it must have been formed by contamination or human remains, human contact.

On examining the copper-to-tin ratios in the metal artifacts of the second group, it was determined that the copper artifacts (bracelets and rings) contained no tin, and that the tin ratio decreased as the copper ratio augmented, or conversely, the copper ratio decreased as the tin ratio augmented. Mirrors 2, 3, 4, 6, and 7 had lead in concentrations of 15.61%, 2.10%, 6.53%, 15.57%, and 7.59%, respectively. An analysis of ancient metallurgical technologies reveals that lead was predominantly employed for casting and constructing intricate shapes. Upon examination of the aforementioned artefacts, it becomes evident that they lack intricate design, being characterized instead by straightforward craftsmanship and simplicity in design. Consequently, it was determined that the alloy's weight was vital in utilizing lead as an additive in the specified artifacts; specifically, the copper artefacts are lightweight, and lead is used to augment their weight. Furthermore, it was demonstrated that tin and lead were utilized alongside copper in objects 2, 3, 4, 6, and 7, indicating that this metallurgical practice is emblematic of Roman and Eastern Roman bronze artefacts and that the age of the metal artefacts corroborates this finding.

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