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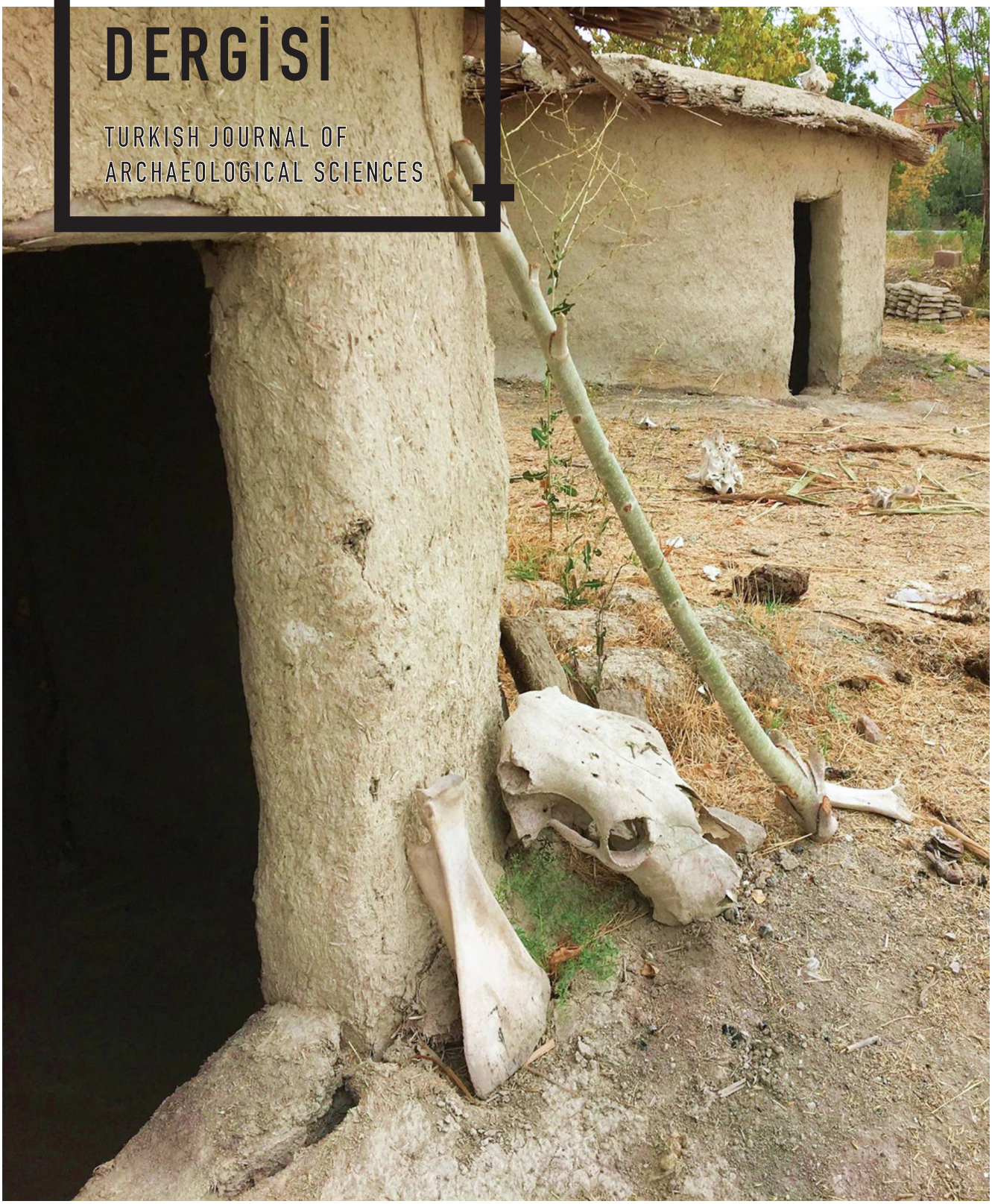

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Abdullah Sokak, No: 17, Taksim / Beyoğlu 34433 İstanbul - Türkiye

Tel: +90 (212) 244 7521 Fax: +90 (212) 244 3209

E.mail: info@zerobooksonline.com

www.zerobooksonline.com

Tasarım / Design

Adnan Elmasoğlu

Uygulama / Layout Design

Hülya Tokmak

Kapak Fotoğrafı / Cover Photo

Gökhan Mustafaoğlu, Boncuklu Höyük Kazı Arşivi/Boncuklu Höyük Excavation Archive

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İçindekiler / Contents

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Editörlerden

Bir yıl sonra yine bir Şubat ayı, beşinci sayımızla herkese merhaba diyoruz. Bu kez birbirinden çok farklı altı yazı ile karşınızdayız. Her biri gerek arkeolojik düşünce yelpazemizin sınırlarını genişleten, alternatif düşünmeye yönlendiren gerek disiplinin kendi içindeki yöntemsel gelişimini gösteren araştırma sonuçları.

Günümüzde var olan ve mücadele içinde olduğumuz çevresel, ekonomik, sosyal pek çok sorunun geçmişte hangi koşullarda nasıl yaşandığı, küçük gruplardan büyük örgütlü toplumlara kadar değişen ve dönüşen yaşamla o dönem koşulları içinde nasıl baş edildiği, toplumların verdikleri tepkileri, geliştirdikleri çözümleri geçmişin derinliklerinde araştıran arkeoloji disiplinine bu sayımızdaki yöntemsel, etnografik, deneysel, yorumlamacı yaklaşımlara sahip yazılarla katkı vermeyi sürdürmenin mutluluğu içindeyiz.

İyi okumalar.

Güneş Duru & Mihriban Özbaşaran

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Note from the editors

A year has passed, and as February returns, we are pleased to present the fifth issue of the Turkish Journal of Archaeological Sciences. This issue brings you six different articles, each offering a unique perspective. Some push the boundaries of archaeological thought, others invite alternative ways of thinking, and some highlight methodological advancements within the field.

Archaeology, as a discipline, seeks to understand how past societies navigated environmental, economic, and social challenges under different conditions. From small-scale communities to large, complex societies, it explores how people adapted to change, responded to crises, and created innovative solutions. In this issue, we are excited to share new research that embraces methodological advances, and ethnographic, experimental, and interpretative approaches, all of them further enriching our understanding of the past.

We hope you enjoy reading!

Güneş Duru & Mihriban Özbaşaran

Sample Preparation and Analytical Instrumentation for Sediment Chemistry Analyses: A Comparative Study of XRF and ICP-MS

Catherine B. Scott[a]

Abstract

For the past few decades, ICP-MS has been the method of choice for studying the chemical composition of sediments and soils on archaeological sites to elucidate past uses of space. However, X-ray fluorescence (XRF) is becoming increasingly a popular alternative due to its flexibility. This study compares sample preparation and analysis of these methods using a dataset of 54 samples from the abandoned 20th century village of Eski Hacıveliler in western Turkey. Several variables were tested, including two methods of powdering (hand-powdering versus ball mill) and two methods of sample preparation for WD-XRF analysis: loose-powder and fused beads. Statistical analyses of the results indicate no significant difference between the results of the two XRF preparations and ICP-MS, though there is a difference in samples powdered by hand versus by ball mill in ICP-MS data. Heat maps of elemental concentrations similarly show agreement between the patterns produced by the XRF and ICP-MS analyses. These results demonstrate the validity of XRF—particularly loose-powder preparations—for archaeological sediment chemistry analysis. This method and sample preparation represent a relatively rapid and low-cost option for analyzing large numbers of samples and, therefore, offer a path toward more extensive incorporation of sediment chemistry into archaeological research.

Keywords: soil chemistry; sample preparation; XRF; ICP-MS; western Turkey

Özet

ICP-MS geçtiğimiz birkaç on yıldır, geçmişteki mekân kullanımını anlamak amacıyla arkeolojik yerleşimlerdeki tortulların ve toprakların kimyasal bileşimini incelemek için tercih edilen

a Postdoctoral Researcher, Research Center for Anatolian Studies, Koç University, Istanbul/Türkiye. catherinescott58@gmail.com ; https://orcid.org/0000-0003-1576-5623 ; Doi: 10.63167/TJAS.2025.4
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bir yöntem olmuştur. Ancak, X-Işını Floresansı (XRF) esnekliği nedeniyle giderek daha yaygın bir seçenek haline gelmektedir. Bu çalışma, Türkiye'nin batısındaki 20.yüzyılda terk edilmiş Eski Hacıveliler Köyü'nden alınan 54 örneklik bir veri setini kullanarak bu yöntemlerin örnek hazırlama ve analizlerini karşılaştırır. Çalışmada iki farklı öğütme yöntemi (elle öğütme ve bilyalı öğütücü) ile WD-XRF analizi için iki farklı örnek hazırlama yöntemi (gevşek toz ve füzyon boncukları) dahil olmak üzere çeşitli değişkenler test edilmiştir. Sonuçların istatistiksel analizleri, iki XRF hazırlama ve ICP-MS sonuçları arasında önemli bir fark olmadığını göstermektedir. Ancak ICP-MS verilerinde elle tozlaştırılan ve bilyalı öğütücüde tozlaştırılan örnekler arasında fark bulunmaktadır. Element konsantrasyonlarının ısı haritaları da benzer şekilde XRF ve ICP-MS analizleri tarafından üretilen örüntüler arasında benzerlik göstermektedir. Bu sonuçlar XRF'in —özellikle örneği gevşek toz şeklinde hazırlamanın— arkeolojik toprak kimyası analizi için geçerliliğini kanıtlamaktadır. Bu yöntem ve örnek hazırlama, çok sayıda örneği analiz etmek için nispeten hızlı ve düşük maliyetli bir seçeneği temsil eder ve bu nedenle toprak kimyasının arkeolojik araştırmalara daha kapsamlı bir şekilde dahil edilmesine yönelik bir yol sunar.

Anahtar Kelimeler: toprak kimyası, örnek hazırlama, XRF, ICP-MS, batı Türkiye

Introduction

Archaeological sediment chemistry (also referred to as soil chemistry analysis) is based on the understanding that human activities impact the chemical composition of the sediments upon which they are performed, and that one can recover patterns produced by structured human behavior by measuring and mapping the composition of archaeological sediments. It has been used to investigate a variety of archaeological questions, including how space was structured in a Viking house (Milek & Roberts, 2013), the location of Maya marketplaces (Anderson et al., 2012; Coronel et al., 2015), and the identification of site boundaries (Bintliff et al., 1992). Although sediment chemistry has great potential to help us understand how humans structured space in the past, it has been underutilized in many parts of the world.

Common barriers to the archaeological use of sediment chemistry include access to laboratories with appropriate instruments and the money needed to fund analysis. Inductively coupled plasma mass spectrometry (ICP-MS) has been a popular method of analysis in sediment chemistry in recent decades because it relatively quickly produces highly accurate measurements[1] for many elements. There are methodological complications with this method, however, and the costs of ICP-MS in terms of equipment, laboratory fees, and sample preparation can be prohibitive for studies with large numbers of samples. It is, therefore, important to explore other methods of analysis in sediment chemistry. By demonstrating the reliability and relative

1 'Accuracy' here refers technically to how closely instrument measurements correspond with the exact concentrations/counts of whatever is measured.

benefits of a variety of analytical methods, it will be possible for more archaeologists to make use of sediment chemistry.

There is already a diverse literature on other approaches to sediment chemistry that range from the use of semi-quantitative spot tests for large molecules (Terry et al., 2000; Barba, 2007; Dore & López-Varela, 2010; Middleton et al., 2010) to the use of portable X-ray fluorescence (XRF) for in-field chemical analysis of sediments (Hayes, 2013; Coronel et al., 2014). Here, I contribute to this conversation by exploring the use of laboratory-based wavelength dispersive (WD) XRF—using both loose-powder and fusion-bead sample preparation—in comparison to ICP-MS.

In recent years, XRF has become an attractive technology for archaeologists in multiple applications in large part because of its flexibility. Laboratory-based machines—like the WD-XRF used in this study—allow for analysis of samples in a variety of physical states: they can analyze processed samples as solid pellets, glass beads, loose-powders, or liquids, each of which present advantages based on the material being studied and which elements are of most interest. XRF can also analyze unprocessed samples, allowing for non-destructive analysis of, for example, artifacts in museum collections. The perceived drawbacks of XRF in comparison to other methods include a more limited range of elements that can be detected and a generally lower sensitivity for trace elements. That said, direct comparisons between XRF and other methods of multi-element analysis are rare in the literature on archaeological sediment chemistry. Such comparisons have focused particularly on testing the validity of portable XRF (pXRF) for field-based soil studies in archaeology; examples include studies comparing pXRF results to ICP-OES (Inductively Coupled Plasma-Optical Emission Spectroscopy) (Gauss et al., 2013; Frahm et al., 2016), AAS (Atomic Absorption Spectroscopy) (Gauss et al., 2013), and DTPA (Diethylenetriaminepentaacetic Acid) chelate extraction of trace metals (e.g., Coronel et al., 2014). Examples focused on laboratory-based XRF analysis include a study by Oonk and colleagues (2009c) that used XRF to test the effectiveness of a weak-acid extraction for ICP-OES analysis, and Cook and colleagues' (2005) study that used ICP-MS to gain additional precision for samples high in certain elements based on XRF analysis. This study, therefore, helps to fill a gap in the literature by directly comparing the results of laboratory XRF and ICP-MS analysis.

This study considers a range of preparation techniques and chemical analyses, involving varying amounts of time, equipment, and access to laboratory spaces. The samples analyzed here come from Eski Hacıveliler, an abandoned 20th century village in the Gediz River valley, western Turkey. I compare the results of WD-XRF analysis, performed on samples prepared both as loose-powder and as fused beads, with results from ICP-MS analysis, performed on samples prepared using a weak-acid extraction. I also discuss the impact of different powdering methods—hand-powdering with a mortar and pestle versus machine-powdering with a ball mill—on the results. Due to the differences between the analytical methods, the comparison of

results focuses primarily on the patterns they produce; these patterns are also the results most comparable to other types of spatial data in archaeology. The results of these comparisons show that different instrumental analyses do not produce statistically significant differences in resultant data patterns. This study, therefore, demonstrates the reliability of laboratory WD-XRF in identifying and studying the chemical remnants of past human activities.

Sediment Chemistry in Archaeology

Archaeological sediment chemistry originated in the early 20th century, when scientists recognized that high concentrations of phosphates in sediments were associated with remains of archaeological sites (Arrhenius, 1931). Phosphorus enters the soil in high quantities in areas where organic waste is left to accumulate, such as middens, manured fields, or areas where food processing or cooking takes place. It is, therefore, useful for both identifying archaeological sites and identifying 'clean' and 'dirty' spaces within them, revealing generally how spaces were structured in the past (Parnell et al., 2001; Roos & Nolan, 2012; Luke et al., 2017). Archaeologists have since realized that other human activities (e.g., cooking, craft production, metalworking) leave characteristic residues where they are performed; patterns of enrichment and depletion of elements, compounds, and large organic molecules, therefore, can be taken as proxies for patterns of past activities. Unfortunately, sediment chemistry has been underutilized in archaeology. Research in Mesoamerica, the UK, and Northern Europe has produced a robust corpus of literature, yet the method is infrequently used in other regions. Furthermore, sediment chemistry is usually applied with limited scope, focusing on small spaces or narrowly defined research questions, rather than being integrated into survey and excavation approaches. This situation is beginning to change as a result of the increased availability of high-quality instrumentation and the development of new methods for chemical analysis.

Chemical analysis of sediments in archaeology has generally focused on measuring concentrations of individual elements, a large number of which can be measured accurately and rapidly using a variety of instruments (e.g., Hjulström & Isaksson, 2009; Coronel et al., 2015); specific elements or suites of elements have been associated with specific activities (e.g., concentrations of lead from Roman metalworking [Cook et al., 2010] or gold from the working of jade [Cook et al., 2006]). Sediment chemistry studies also generally involve the comparison of chemical patterns with other spatial datasets (e.g., artifact and ecofact distribution, architecture) (Cook et al., 2006; Milek & Roberts, 2013).

The degree of analytical precision necessary to produce meaningful patterns remains a topic of discussion in this field. Do measurements need to reflect the exact elemental concentrations of samples? Are strictly quantitative measurements required, or are semi-quantitative measurements (e.g., spot tests [Rypkema et al., 2007]) sufficient to produce meaningful results? Oonk

and colleagues (2009a), for example, argue that the best way to achieve a complete understanding of anthropogenic inputs into the soil is to combine sequential extraction, which isolates each fraction of the soil matrix for ICP analysis, and other types of mineralogical analyses (e.g., X-ray diffraction [XRD]). Such detailed analysis does allow for a direct comparison of raw concentration between samples because it quantifies variation from local environmental and soil formation processes; however, it requires significantly more resources than is practical for most archaeological projects, especially those with sample numbers in the hundreds. Almost all studies using sediment chemistry, therefore, use a method that produces imperfect or incomplete data—whether via partial extractions for ICP-MS or bulk sediment analysis with XRF. Arguably, as long as a method produces meaningful patterns that are internally consistent and help answer research questions, it is 'archaeologically valid' (Frahm & Doonan, 2013).

Materials and Methods

Site Description and Sampling Method

The samples used in this study were collected from Eski Hacıveliler, a village located in the Gediz River valley, western Turkey. The village, formed between 1919 and 1922 and largely abandoned by the 1980s, consists primarily of vernacular architecture with stone foundations and mudbrick superstructures, most in a state of ruin today owing to a combination of intentional destruction (see Luke & Cobb, 2013) and natural degradation (O'Grady et al., 2018). The village is organized into three neighborhoods around public spaces including a mosque and minaret, fountain, and public garden; a school lies on the outskirts of the village, with a still-used cemetery nearby (Luke & Cobb, 2013). Archaeologists, anthropologists, and conservators studied Eski Hacıveliler under the Central Lydia Archaeological Survey (CLAS) (Roosevelt & Luke, 2012, 2013, 2014), and it remains a useful site of experimental archaeology and ethnoarchaeology.

Samples were collected from Eski Hacıveliler over the course of two days in the summer of 2013. A targeted sampling strategy focused on features of interest in three areas of the village, sometimes on an improvised grid. Area 1 was the interior of the schoolhouse, constructed of local mudbrick atop schist fieldstone foundations. Area 2 surrounded the public fountain constructed of stone, used for watering animals and doing laundry, among other things. Samples were taken primarily from the ground around and above this feature. Area 3 was the house of a wealthy family in the middle neighborhood (Luke & Cobb, 2013). Samples were collected from within the mudbrick house and its enclosed courtyard.

A total of 54 samples were collected into plastic bags using a metal trowel and wrapped in aluminum foil; between samples, the trowel was washed with 1M HCl and deionized water. The location of each sample was recorded using a Real-Time Kinematic GNSS (RTK-GNSS) system and mapped using GIS software.

Sample Preparation and Analysis

Given the small number but relatively large volume of samples from Eski Hacıveliler (ca. 7-10 g), the dataset presented an opportunity to experiment with different methods of analysis. To this end, this study utilized three types of sample preparation and analysis available at the Koç University Surface Science and Technology Center (KUYTAM) in Istanbul, Turkey. The first two types of analysis utilized laboratory WD-XRF with samples prepared according to two preparation protocols: loose-powder and fused beads. The third type of analysis employed microwave-assisted acid-digestion and ICP-MS analysis. The following sections discuss processes of sample preparation and analyses, followed by a discussion of their differential effects on analysis results.

Sample Homogenization

The first step in sample preparation was powdering, which serves to homogenize the sample and reduce grain size, thereby facilitating digestion/fusion. Sample powdering took place in facilities provided by the Department of Earth and Environment at Boston University and employed two methods of powdering due to the nature of the equipment available. Samples greater than 8 grams (the minimum sample size for the available equipment) were powdered in a ball mill with an agate chamber and agate balls, which were cleaned at the beginning of the day and between each sample with Ottawa quartz sand and isopropanol. Samples less than 8 grams were powdered by hand using an agate mortar and pestle, which was also cleaned at the beginning of each day and between each sample with Ottawa quartz sand and isopropanol. In all cases, sediment fractions greater than 2 mm were removed, either by hand or by sieving through a mesh, prior to powdering. Thirty-five samples were recorded as being powered by hand and nine by ball mill; the powdering method was not recorded for 10 samples due to a data entry error.

X-Ray Fluorescence Spectrometry

XRF is a popular tool for compositional analyses in archaeology because it can be non-destructive and has options for portability. The use of XRF for sediment chemistry is not as common as its use for other materials, but this is beginning to change (Cook et al., 2010; Cook et al., 2014). The relative speed and ease of some types of XRF analysis make it possible to analyze a larger number of samples than was possible in previous studies, allowing archaeologists to cover larger areas or to increase sampling resolution. XRF analysis also provides near total analysis of the sample, while methods such as ICP-MS often do not.

The use of XRF for sediment analyses is not without complications. Sediment is a complex, variable material, which can make it difficult to differentiate between multiple anthropogenic inputs (e.g., from ancient occupation versus modern pollution or agriculture) and natural inputs (Oonk et al., 2009a, 2009b, 2009c; Dore & López Varela, 2010; López Varela & Dore,

2010). Certain complexities fundamental to the physics of the method also must be taken into account. If a sample is insufficiently prepared, the analysis may not capture the full range of variation within the sample or may be impacted by matrix effects or the internal geometry of the sample (Pollard et al., 2007). The utility of XRF analysis of sediment is, therefore, dependent on how the sample is prepared prior to analysis. Archaeologists must balance effective preparation with considerations of time and cost.

Most archaeological sediment studies that utilize laboratory XRF analysis prepare samples by pressing the sediment into pellets (Oonk et al., 2009a, 2009c; Abrahams et al., 2010; Cook et al., 2014). This method has the advantage of both homogenizing the sample and producing a solid, smooth surface with which the primary X-rays can interact. However, this method requires a comparatively large amount of sediment, which may be difficult to recover from archaeological contexts and which averages the chemical signatures of a larger area. Some recent studies have focused instead on loose-powder preparations—particularly those occurring in the field and using pXRF rather than laboratory XRF, as in this study—with varying methods of sample homogenization (Gauss et al., 2013; Coronel et al., 2014; Frahm et al., 2016). For this study, two sample preparations that are less frequently used in archaeological sediment chemical studies using WD-XRF were tested: loose-powder and fusion-bead preparation.

Loose-powder preparation is the quickest type of sample preparation and the one requiring the least specialized equipment. It also allows for the easy re-analysis of soil samples if only a small amount of material is available, whether for sediment chemistry or other analyses. One disadvantage is that it does not produce a stable sample that can be reanalyzed under the exact same conditions. Studies utilizing pXRF, whether in the field or in the laboratory, employ a loose-powder sample preparation and have determined that results generally compare favorably with other types of analysis for most elements of interest (Gauss et al., 2013; Coronel et al., 2014). For this study, samples were weighed into plastic cups that were closed with Chemplex prolene film.

The fusion-bead preparation involves firing the sample to oxidize it and to determine the loss on ignition of any volatiles or organic material, mixing it with a flux, melting it, then cooling it into a glass bead. This preparation method is comparatively labor- and cost-intensive but achieves the most effective homogenization and produces uniform a matrix that is least susceptible to geometric complications as the X-rays pass through it. The fusion-beads have also been shown to produce more accurate results as compared to pellets, although both methods are equally precise (Anzelmo et al., 2014). For this study, samples were mixed with a lithium tetraborate flux at an approximate 8:1 ratio and fused using a Fluxana Vulcan 2MA at KUYTAM in Istanbul.

Both fusion-bead and loose-powder analyses were conducted using a Bruker Tiger S8 X-ray fluorescence spectrometer at KUYTAM. The machine was calibrated using 4 standard glass beads (STG2, SQ1, SQ2, SQ3) and graphite, boron nitride (BN), Al, and Cu standards for all sample types. STG is a mixture of Na, Al, Si, S, Cl, K, Ca, Fe, Sr, and Sb. Zn, N, C, and P alignments are adjusted with SQ1, BN, graphite, and SQ2 standards.

Inductively Coupled Plasma Mass Spectrometry

ICP-MS is currently one preferred type of analysis in sediment chemistry, particularly for measuring concentrations of trace elements. This technique is highly sensitive and precise, allowing for the near simultaneous measurement of a wide range of elements. Samples are typically powdered and then digested in acid so that they are introduced to the machine in a liquid state (Neff, 2017).

As is the case with XRF, a number of complications are specific to the use of ICP-MS. Whereas XRF results represent 'bulk-sample' analyses, ICP-MS analysis represents the fraction of sedimentary material extracted through acid digestion. Elements of interest to archaeologists might be contained in multiple mineral fractions, though it is generally thought that accessible fractions are more likely to represent anthropogenic inputs while more stable fractions are more likely to represent natural inputs (see e.g., Haslam & Tibbett, 2004). Weak-acid digestions, which extract accessible fractions and discard others, have often been thought to be the most appropriate for archaeological chemistry (Middleton & Price, 1996; Oonk et al., 2009c; Misarti et al., 2011; Salisbury, 2013). However, Oonk and colleagues (2009c) argue that the environment and soil formation processes at some sites might lead to anthropogenic signals being stored in sediment fractions that are missed by weak-acid extractions. Their comparison of weak-acid extraction for ICP-OES with a total analysis from XRF mentioned above showed that some anthropogenic phosphorus, for example, might be stored in more stable fractions at some sites, particularly those with clayey soils (Oonk et al., 2009c, 1220). Strong acid digestions, which access fractions that are more stable within the matrix, are also used in some cases (Cook et al., 2005; Entwistle et al., 2007). An ideal method would involve sequential extraction, isolating the signal from various fractions within the matrix rather than isolating one or two (Oonk et al., 2009a); however, sequential extraction is a labor-intensive process, especially for archaeological projects that may require the analysis of dozens or hundreds of samples to provide adequate coverage of an area of interest, and may ultimately collect more data than is realistically necessary for some studies.

For the purposes of this study, samples were digested according to US EPA protocol 3051a, which is a microwave-assisted digestion protocol utilized by Cook and colleagues (2006) and similar to other weak-acid extraction methods used in other studies. This protocol does not

produce a sample that is representative of the bulk sediment. Therefore, whereas results from the XRF analyses reflect the total contents of the sample, the results from this analysis reflect only the digested fraction of the sample. The samples were analyzed on an Agilent 7700x ICP-MS at KUYTAM; SRM-679 was used as a standard to determine the accuracy of the machine during analysis.

Statistical and Geospatial Analyses

A variety of statistical and geospatial analyses were used to compare the datasets produced by each method of analysis. To compare powdering methods, a simple one-way analysis of variance (ANOVA) test was performed using JMP Pro 13 software to compare results from samples powdered by hand versus by a ball mill for elements detected in all three methods of analysis.

Directly comparing the concentrations produced by each method of analysis was particularly complicated. Because each method of analysis resulted in the measurement of a different number of elements from each sample, element concentrations were converted into ranks, with the rank indicating how concentrated each element was in that particular sample. For example, in a sample with results for 14 elements, iron (1300 ppm) was ranked 14 because it was the most concentrated element; copper (65 ppm) was ranked 1 because it was the least concentrated element in the sample. Friedman's test was then used to compare rankings across samples to determine if analytical methods produced statistically significant differences.

To compare geospatial patterns produced by the data, heat maps showing the distribution of specific elements across collection areas were interpolated using the Inverse Distance Weighted tool in ArcMap. Rather than map raw concentrations, results were transformed to reflect enrichment and depletion relative to a calculated 'background' (Cook et al., 2006). The background was defined as the robust mean of all samples from each dataset; this mean was then subtracted from the concentration of each sample, and the result was divided by the robust standard deviation in order to produce a measurement of the enrichment/depletion of each sample relative to the mean. These maps were then compared visually.

Results

Powdering Method

Table 1 shows the results of ANOVA tests of the powdering method. For the loose-powder and fusion-bead datasets, the results showed no statistically significant difference between powdering methods for most elements. However, for the ICP-MS dataset, the test did show a statistically significant difference for most elements. This suggests that the method of sample homogenization has more impact on acid digestion than on sample preparation methods for XRF. However, the imbalance in the number of samples homogenized with each method

(35 versus 9) means that this statistical comparison is not very robust, and the results should be seen as tentative.

Table 1. *p*-values from a one-way ANOVA test, run to determine if there is a significant difference between powdering methods. (* indicates $p < 0.05$).

Element	Loose-powder XRF	Fusion-bead XRF	ICP-MS
Al	0.0252*	0.8018	0.0045*
Fe	0.4008	0.8115	0.0016*
K	0.1274	0.9164	0.0019*
Ca	0.0769	0.0552	0.0215*
Mg	0.8195	0.5629	0.0114*
Ti	0.7351	0.8054	0.0103*
Na	0.0448*	0.0467*	0.2315
Mn	0.1803	0.2962	0.0023*
Ba	0.5764	0.1820	0.0010*
Cu	0.5415	0.3121	0.0524*
As	0.5129	0.4109	0.0751
Cr	0.8216	0.0509	0.0870
Rb	0.7829	0.06074	0.6842
Sr	0.5488	0.0150*	0.0027*

XRF Analyses versus ICP-MS Analysis

Each method produced data for a different set of elements, although all produced data on elements of typical archeological interest (Table 2). ICP-MS analysis measured the largest number of elements (54; 29 of which are robust[2] enough for statistical analysis). XRF analysis on loose-powder and fusion-bead samples produced data on 26 (13 with robust data) and 25 (20 with robust data) elements, respectively; both analyses covered most elements of interest except manganese, for which loose-powder analysis produced no robust data. Some samples in the fusion-bead XRF dataset proved to be problematic: 13 samples lacked data because of an insufficient amount of material for analysis. The statistical results below, therefore, represent 41 samples for which all three methods produced robust data.

2 Here, 'robust' means that most or all samples produced data on a given element; for some elements, data were produced for some samples but not enough for statistical comparison. Lack of data is most often due to the concentration for a given element being below the detection limits of the machine; however, in the case of phosphorus, this appears to be the result of a problem with the machine during analysis of part of the dataset.

Table 2. All elements for which robust data were reported, and which method of analysis provided data on which elements (X = data; -- = no data; *indicates elements of general interest in archaeology).

Element	Loose-Powder XRF	Fusion-Bead XRF	ICP-MS
Aluminum	X	X	X
Antimony	--	--	X
Arsenic	--	X	X
Barium	--	X	X
Calcium*	X	X	X
Cerium	--	--	X
Cesium	--	--	X
Chromium	--	X	X
Cobalt	--	--	X
Copper*	X	X	X
Europium	--	--	X
Gadolinium	--	--	X
Holmium	--	--	X
Iron*	X	X	X
Lanthanum	--	--	X
Lead	--	--	X
Magnesium*	X	X	X
Manganese*	--	X	X
Neodymium	--	--	X
Nickel	--	X	--
Phosphorus*	X	X	--
Potassium*	X	X	X
Rubidium	--	X	X
Silicon	X	X	--
Sodium*	X	X	X
Strontium*	X	X	X
Sulfur	X	X	--
Tantalum	--	--	X
Thorium	--	--	X
Titanium	X	X	X
Uranium	--	--	X
Vanadium	--	--	X
Ytterbium	--	--	X
Yttrium	X	--	X
Zinc	--	X	--
Zirconium	--	X	--

Tables 3-5 and Figure 1 show the ranking of elements for three samples: 930.698.1.1, 932.698.2.1, and 974.697.5.1. Using Friedman's test, the *p*-value was determined to be above 0.05 for all samples; therefore, this test does not provide enough evidence to indicate a statistically significant difference between ICP-MS, loose-powder WD-XRF, and fusion-bead WD-XRF. It is important to note, however, that because of the conversion to ranks, this test does not compare the actual concentrations of elements. Raw concentrations can vary significantly as a result of several factors, including instrument detection limits for various elements, effects of sample preparation, and the fact that XRF results represent all fractions of the sediment while ICP-MS does not.

Table 3. Concentrations and ranks for sample 930.698.1.1; loss on ignition for the FB-XRF analysis was 11.2% of the original sample volume. Concentrations are in parts per million (ppm).

Concentrations				Ranks			
Element	**FB-XRF**	**ICP-MS**	**LP-XRF**	**Element**	**FB-XRF**	**ICP-MS**	**LP-XRF**
Al	65362.38	112069.88	111618.83	Al	14	13	14
As	454.43	2066.2	681.65	As	6	8	6
Ba	716.27	988.69	1701.15	Ba	7	5	7
Ca	27373.01	22700.95	51887.22	Ca	12	10	12
Cr	205.26	366.98	342.1	Cr	4	4	4
Cu	79.89	150.29	78.00	Cu	3	2	1
Fe	44763.52	201548.88	74279.47	Fe	13	14	13
K	22414.32	30207.21	42089.11	K	11	11	11
Mg	8443.4	30676.44	14474.4	Mg	10	12	10
Mn	387.23	1728.94	619.57	Mn	5	6	5
Na	5712.32	4425.01	4006.04	Na	8	9	8
Rb	77.00	0	182.88	Rb	2	1	3
Sr	73.00	151.83	84.56	Sr	1	3	2
Ti	6414.76	1851.58	8033.43	Ti	9	7	9

Table 4. Concentrations and ranks for sample 932.698.2.1; loss on ignition for the FB-XRF analysis was 19.3% of the original sample volume. Concentrations are in parts per million (ppm).

Concentrations				Ranks			
Element	FB-XRF	ICP-MS	LP-XRF	Element	FB-XRF	ICP-MS	LP-XRF
Al	58958.45	16787.47	113047.80	Al	13	13	14
As	227.22	187.28	530.17	As	3	6	5
Ba	716.27	146.15	1522.08	Ba	5	5	7
Ca	19368.37	5266.89	41238.19	Ca	10	10	11
Cr	1505.24	32.88	273.68	Cr	6	3	4
Cu	79.89	30.89	69.00	Cu	1	2	1
Fe	39168.08	25202.79	71201.97	Fe	12	14	13
K	19591.78	7990.99	42338.16	K	11	11	12
Mg	6754.72	4198.59	12363.55	Mg	9	9	10
Mn	619.57	454.78	1239.14	Mn	4	8	6
Na	4154.42	11357.96	3635.11	Na	7	12	8
Rb	90.00	85.72	182.88	Rb	2	4	3
Sr	90.00	21.80	169.19	Sr	2	1	2
Ti	4796.08	283.63	7433.92	Ti	8	7	9

Table 5. Concentrations and ranks for sample 974.697.5.1; loss on ignition for the FB-XRF analysis was 9.6% of the original sample volume. Concentrations are in parts per million (ppm).

Concentrations				Ranks			
Element	FB-XRF	ICP-MS	LP-XRF	Element	FB-XRF	ICP-MS	LP-XRF
Al	64039.25	14815.80	103785.93	Al	14	13	14
As	416.56	331.22	530.17	As	5	7	5
Ba	725.56	140.82	1343.01	Ba	7	4	7
Ca	30446.22	11183.01	49457.24	Ca	12	12	12
Cr	88.95	46.98	136.84	Cr	2	3	4
Cu	103.85	44.71	58.00	Cu	4	2	1
Fe	41630.07	31773.78	54625.48	Fe	13	14	13
K	23244.48	3758.40	37357.20	K	11	10	11
Mg	7960.92	4438.33	13087.27	Mg	10	11	10
Mn	577.75	439.33	774.46	Mn	6	8	6
Na	4525.35	982.23	2967.44	Na	8	9	8
Rb	91.44	222.88	91.44	Rb	3	5	2
Sr	59.19	40.45	92.00	Sr	1	1	3
Ti	5959.13	276.16	5995.10	Ti	9	6	9

Heat maps produced in ArcMap show another perspective on how patterns from the three methods interrelate. Figures 2-4 show heat maps of Area 3 for three elements typically included in archaeological sediment chemical studies: calcium, magnesium, and phosphorus. The results are very similar among the three methods of analysis, indicating that similar patterns are produced regardless of differences in raw concentration. Trace elements of interest to archaeologists—such as strontium and copper—show more variation between the maps. Strontium shows patterns that are broadly similar but not identical in the three methods (Figure 5); this pattern is replicated in the results from Area 1 (Figure 6). Copper, on the other hand, shows a significant outlier in the fusion-bead map that does not appear in the other maps (Figure 7). The ICP-MS and loose-powder XRF maps show broadly similar patterns—particularly that the highest concentration is in the southeastern corner—which are also similar to the pattern in the fusion-bead dataset with the outlier removed. Figure 8 shows that the relationship between copper patterns in the two XRF datasets are perhaps a little more similar in Area 2, but the patterns still diverge. Inconsistencies in the patterns produced by the three methods were also seen in those elements that are most likely lithogenic rather than anthropogenic in this context, such as potassium and aluminum (Figures 9-10). While potassium is usually considered to be an element of anthropogenic interest in sediment chemistry (Oonk et al., 2009b; Gauss et al., 2013), the high concentration of potassium found in a bedrock sample from a site on the same mountain ridge as Eski Hacıveliler indicates that this element is likely not indicative of anthropogenic inputs in this local environment (Scott, 2020). Notably, variation between the patterns was more pronounced in the heat maps for aluminum than in the heat maps for potassium.

Discussion

The results presented above provide suggestions about the relationship between these methods and the data they produce, as well as some tentative guidelines for how to plan chemical analysis in a sediment chemistry study.

First, comparison of powdering methods suggests that they have a stronger impact on results for ICP-MS than for XRF (either preparation), which is consistent with expectations. Although grain size can impact how an X-ray moves through and interacts with a sample in loose-powder analysis, the acid digestion for ICP-MS sample processing is the most likely preparation process to be impacted by grain size. Larger grains would take more time to break down and might not do so fully within the time allotment in the protocol. If one has time and access to a laboratory with appropriate materials, it is worth finding and using a ball mill to powder samples rather than powdering by hand. If one is interested in reducing the amount of equipment and laboratory time required, however, or if one is interested in doing sample prep and/or analysis in the field, powdering by hand is sufficient for preparing samples for XRF analysis.

Second, the statistical analyses indicate that there is no statistically significant difference between the datasets, but the heat maps suggest a more complicated picture. While the patterns produced for major elements of anthropogenic interest (e.g., calcium, magnesium, phosphorus) are consistent between methods, the patterns produced for trace elements (e.g., strontium, copper) are less so. These elements show general similarity in patterning (for example, enrichment of strontium in the northwest and southeast with lower concentrations in between [Figure 5]), but they are certainly not as similar as the major elements. A possible explanation for this is the small range in values for trace elements relative to major elements. Although the degree of enrichment/depletion is sometimes similar, the range in raw concentrations for trace elements (e.g., strontium 1CP-MS range in Area 3 = 43.9 ppm, 17.4% of the dataset range) is much smaller than for major elements (e.g., calcium ICP-MS range in Area 3 = 48,750.5 ppm, 92.9% of the dataset range). Patterns in trace elements may result from soil formation processes rather than being indicative of differences in the use of space by humans in the past.

Indeed, one generally expects anthropogenic activity to produce outliers in the distribution of elements across a space. Figure 7 shows a copper outlier in the fusion-bead XRF dataset, which is indicative of the enrichment of copper due to human activity. This outlier is most likely the result of copper-rich particles in the sample aliquot analyzed via fusion-bead analysis, emphasizing the importance of homogenization prior to analysis.

The heat maps of primarily lithogenic elements also show some inconsistencies between the three methods. Potassium shows relatively similar patterns between the ICP-MS and loose-powder XRF datasets yet diverges in the fusion-bead XRF dataset, as was the case for strontium and copper. As with the copper distribution pattern, the removal of a significant outlier in the fusion-bead XRF dataset brings the patterns produced by the three methods closer, although by no means totally, into line. That copper and potassium, as well as calcium and aluminum, show outlier values in the same sample suggests that the outlier values are real, whether deriving from the composition of the original sample or introduced erroneously during processing or analysis. Aluminum shows more significant differences between the methods, suggesting that methods of analysis should be considered carefully in studies focusing on aluminum distribution. This should not be a problem for most projects using sediment chemistry; however, aluminum and other lithogenic elements like it are generally not elements of interest in studies focusing on human activity.

Conclusions

The patterns seen in this dataset indicate the following. First, for major elements of interest, there is almost no difference in the patterns produced by different methods of analysis. Second, in cases where there is more variation between methods of analysis, ICP-MS and loose-powder

XRF seem to produce results that are more consistent with each other than fusion-bead XRF (this may be, in part, the result of sub-dividing the sample for analysis). These results confirm that loose-powder XRF is a reliable substitute for ICP-MS analysis if one is interested in reducing the cost in time and money associated with chemical analysis of sediments, with the caveat that extra care should be taken when interpreting patterns of trace elements. Additionally, the results suggest that hand-powdering of samples is sufficient for XRF analysis, but that powdering with a ball mill would be preferable if one is available.

Perhaps a better way to think about the relationship between loose-powder XRF and ICP-MS is to consider how they can work together to facilitate the better integration of sediment chemistry into archaeological workflows. In cases where it would be advantageous to analyze a large number of samples quickly (for example, if one seeks to explore the use of space across an entire site), loose-powder XRF can reduce the cost of exploratory analysis that can provide data on broad patterns of spatial organization. This sort of study can also identify areas where targeted analysis might provide additional insights, in which case a more accurate method like ICP-MS would be preferable. An example of this can be found in Cook and colleagues' (2005) study of a first to second century CE Roman house complex in the UK, where samples rich in copper, zinc, and lead based on XRF analysis were further tested for gold, silver, and tin with an ICP-MS. Using a loose-powder preparation would have an additional advantage in such a study; samples are not consumed by XRF analysis and could be easily re-analyzed using XRF or further processed for ICP-MS analysis, depending on the needs of the study.

Sediment chemistry is a powerful tool for understanding how humans used and structured space in the past. This study demonstrates that by utilizing the variety of analytical methods available today, this important methodology can be made available and efficient for a wide range of archaeological projects.

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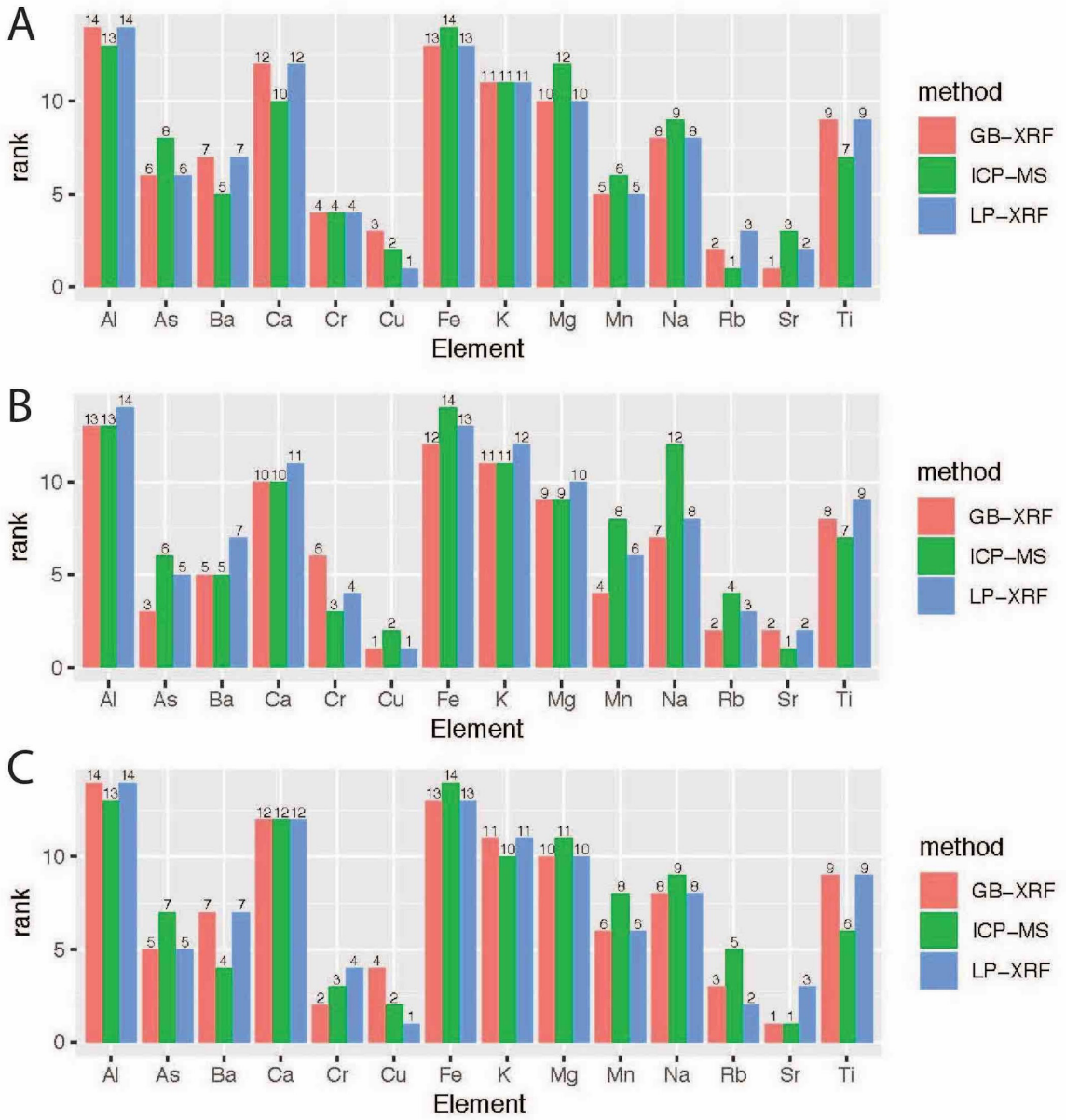

Figure 1. Rankings for samples A) 930.698.1.1, B) 932.698.2.1, and C) 974.697.5.1.

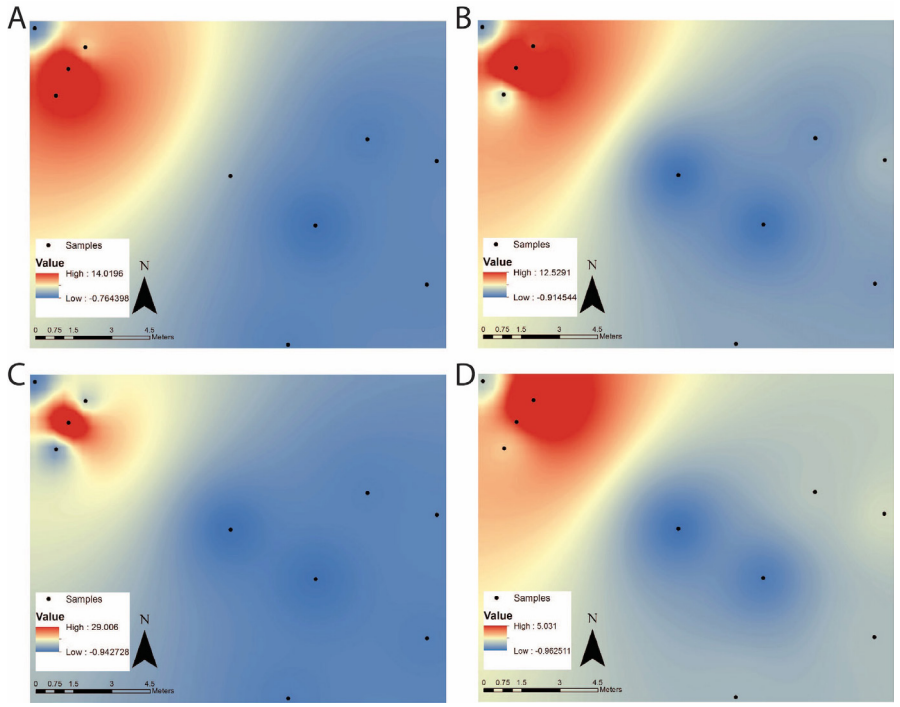

Figure 2. Heat maps showing the distribution of calcium in Area 3 from A) ICP-MS analysis, B) loose-powder XRF, C) and fusion-bead XRF with a major outlier and D) without. Values indicate enrichment or depletion relative to a calculated background.

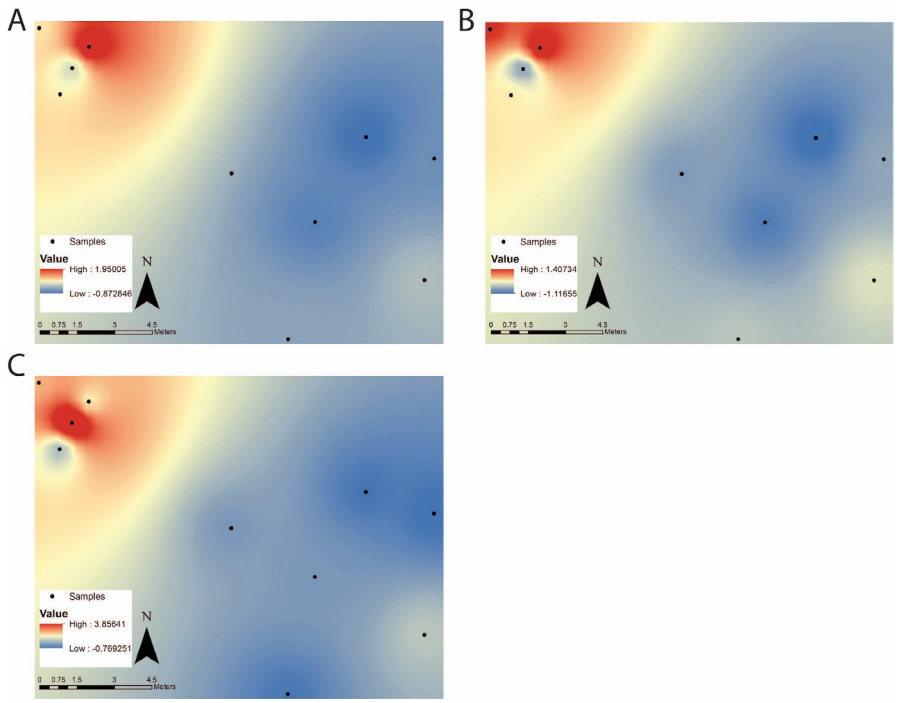

Figure 3. Heat maps showing the distribution of magnesium in Area 3 from A) ICP-MS analysis, B) loose-powder XRF, and C) fusion-bead XRF. Values indicate enrichment or depletion relative to a calculated background.

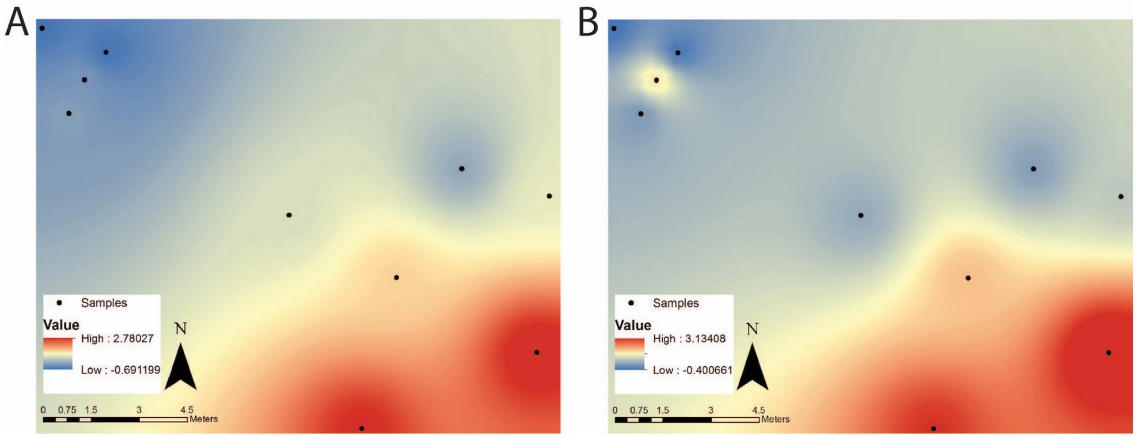

Figure 4. Heat maps showing the distribution of phosphorus in Area 3 from A) loose-powder XRF and B) fusion-bead XRF. ICP-MS produced no data for this element. Values indicate enrichment or depletion relative to a calculated background.

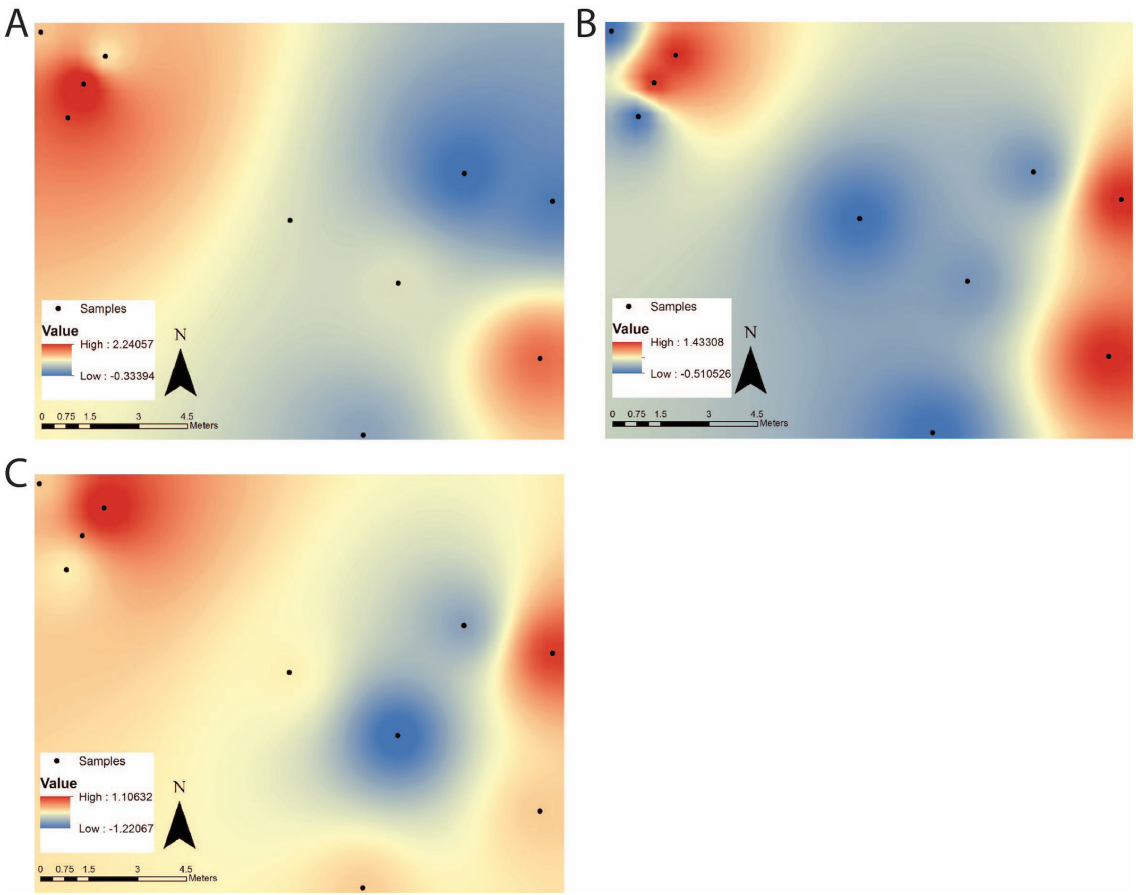

Figure 5. Heat maps showing the distribution of strontium in Area 3 from A) ICP-MS analysis, B) loose-powder XRF, and C) fusion-bead XRF. Values indicate enrichment or depletion relative to a calculated background.

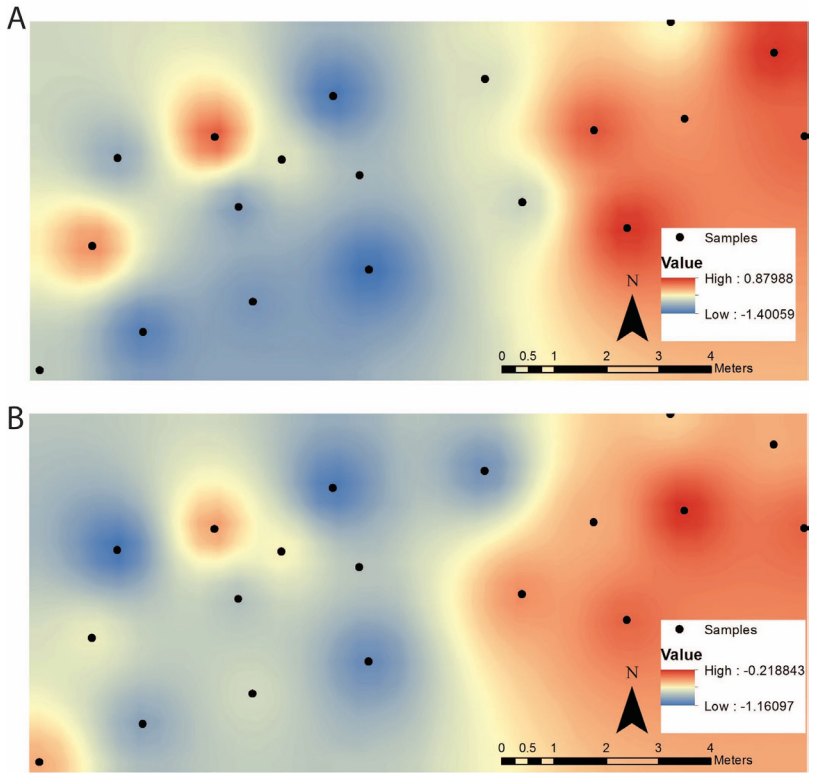

Figure 6. Heat maps showing the distribution of strontium in Area 1 from A) ICP-MS analysis and B) loose-powder XRF. Values indicate enrichment or depletion relative to a calculated background.

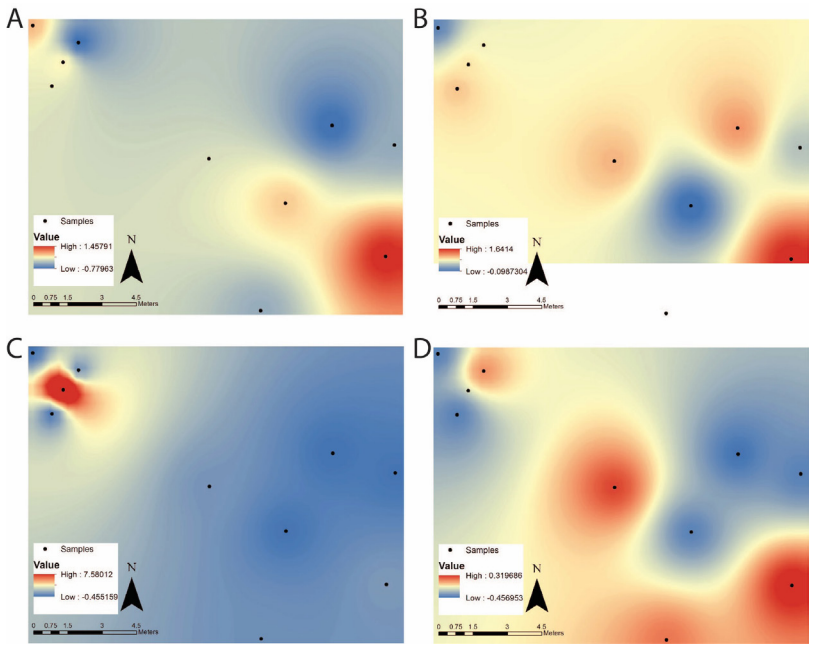

Figure 7. Heat maps showing the distribution of copper in Area 3 from A) ICP-MS analysis, B) loose-powder XRF (map is truncated because of missing data), C) fusion-bead XRF including a significant outlier, and D) fusion-bead XRF without the outlier. Values indicate enrichment or depletion relative to a calculated background.

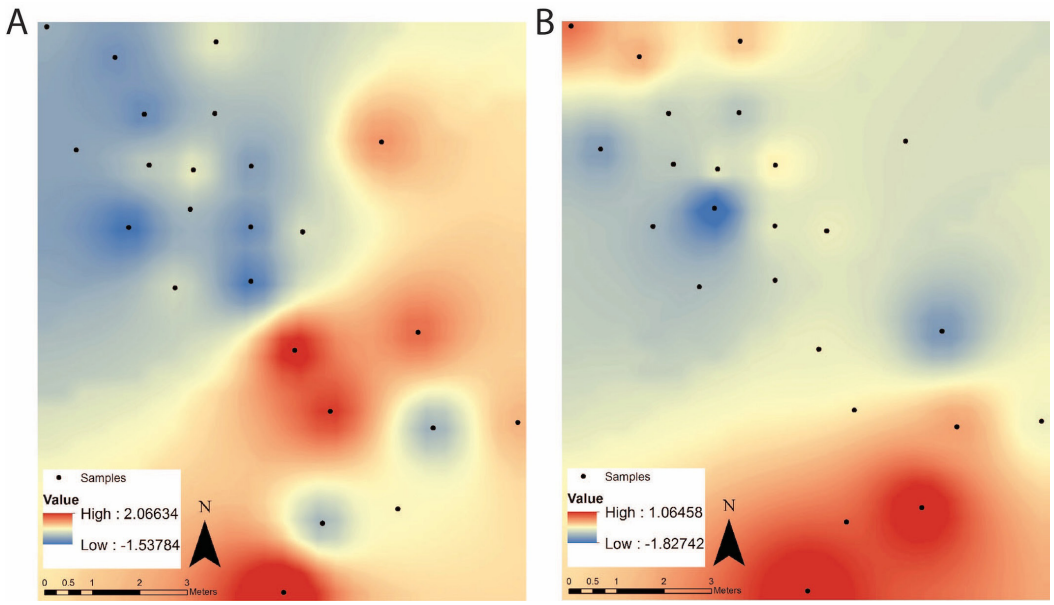

Figure 8. Heat maps showing the distribution of copper in Area 2 from A) loose-powder XRF and B) fusion-bead XRF. Values indicate enrichment or depletion relative to a calculated background.

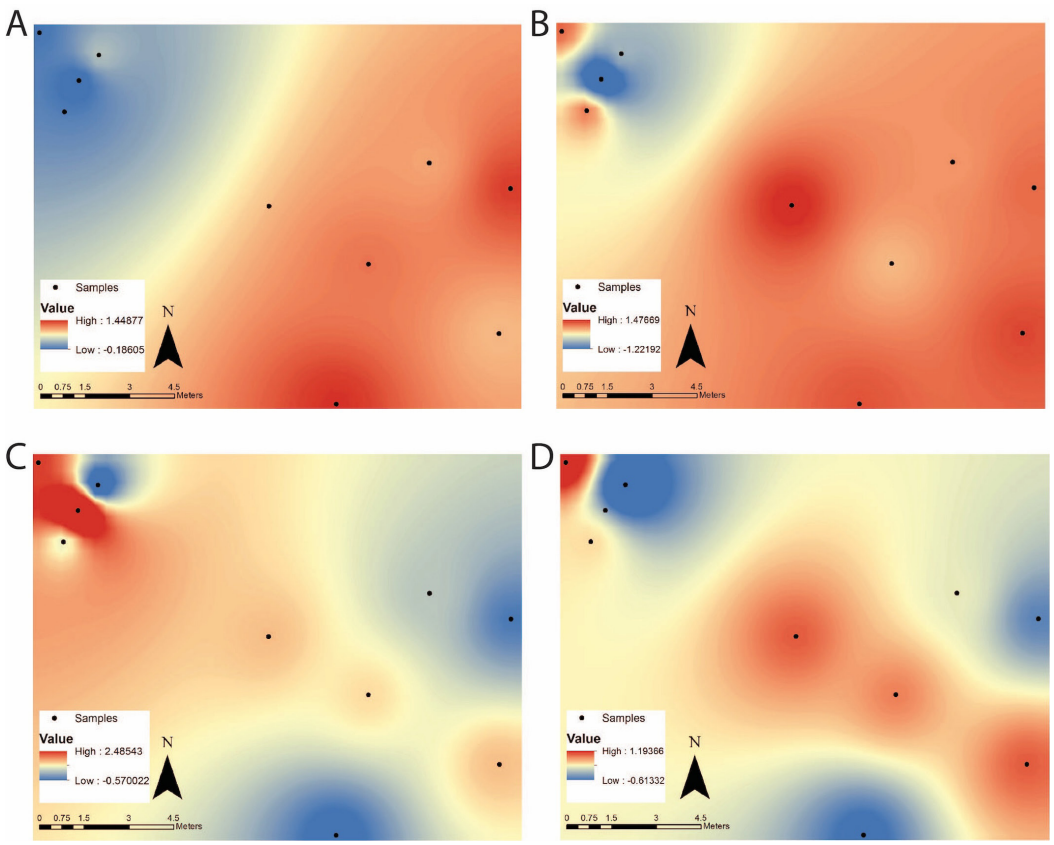

Figure 9. Heat maps showing the distribution of potassium in Area 3 from A) ICP-MS analysis, B) loose-powder XRF, C) fusion-bead XRF including a significant outlier, and D) fusion-bead XRF without the outlier. Values indicate enrichment or depletion relative to a calculated background.

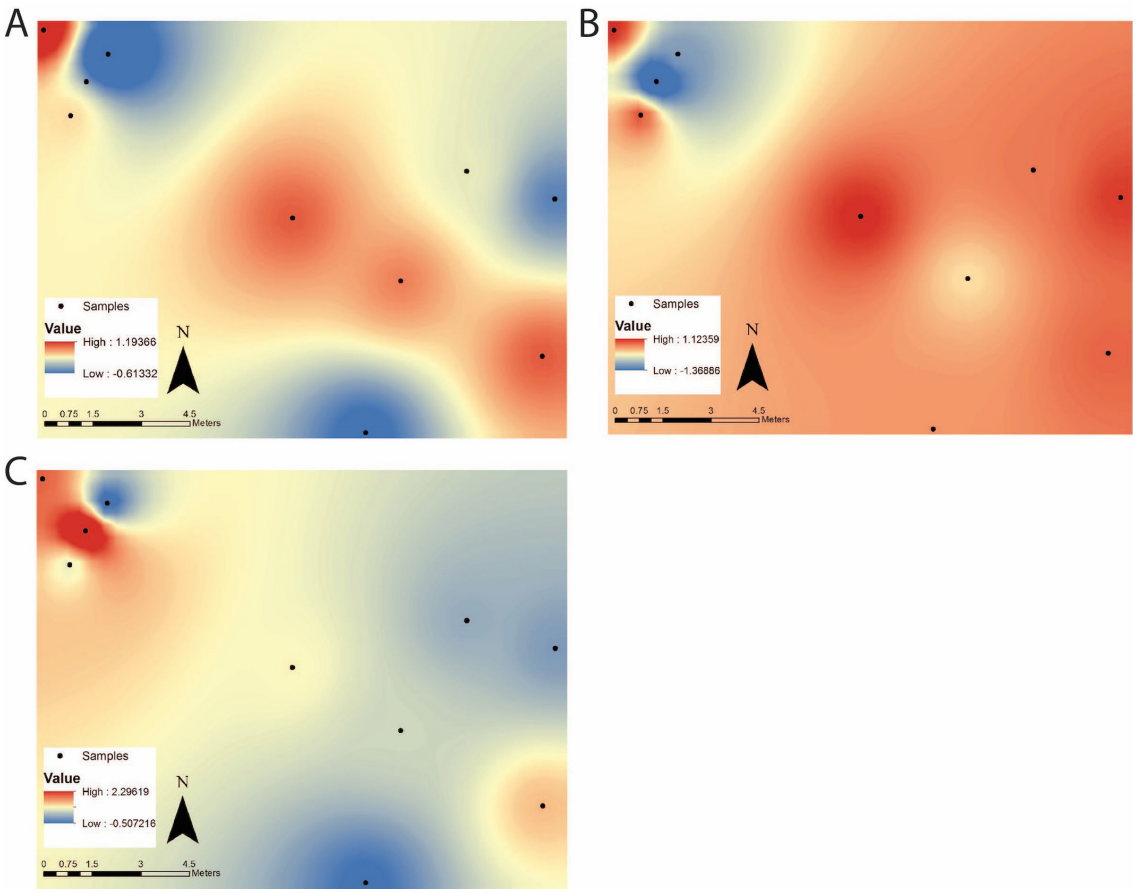

Figure 10. Heat maps showing the distribution of aluminum in Area 3 from A) ICP-MS analysis, B) loose-powder XRF, and C) fusion-bead XRF. Values indicate enrichment or depletion relative to a calculated background.

ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Amaç & Kapsam

Arkeoloji bir süredir geçmişin yorumlanmasında teknoloji ve doğa bilimleri, mühendislik ve bilgisayar teknolojileri ile yoğun iş birliği içinde yeni bir anlayışa evrilmektedir. Üniversiteler, ilgili kurum ya da enstitülerde yeni açılmakta olan "Arkeoloji Bilimleri" bölümleri ve programları, geleneksel anlayışı terk ederek değişen yeni bilim iklimine adapte olmaya çalışmaktadır. Bilimsel analizlerden elde edilen sonuçların arkeolojik bağlam ile birlikte ele alınması, arkeolojik materyallerin, yerleşmelerin ve çevrenin yorumlanmasında yeni bakış açıları doğurmaktadır.

Türkiye'de de doğa bilimleriyle iş birliği içindeki çalışmaların olduğu kazı ve araştırma projelerinin sayısı her geçen gün artmakta, yeni uzmanlar yetişmektedir. Bu nedenle Arkeoloji Bilimleri Dergisi (ABD), Türkiye'de arkeolojinin bu yeni ivmenin bir parçası olmasına ve arkeoloji içindeki arkeobotanik, arkeozooloji, alet teknolojileri, tarihlendirme, mikromorfoloji, biyoarkeoloji, jeokimyasal ve spektroskopik analizler, Coğrafi Bilgi Sistemleri, iklim ve çevre modellemeleri gibi uzmanlık alanlarının çeşitlenerek yaygınlaşmasına katkı sağlamayı amaçlamaktadır. Derginin ana çizgisi arkeolojik yorumlamaya katkı sağlayan yeni anlayışlara, disiplinlerarası yaklaşımlara, yeni metot ve kuram önerilerine, analiz sonuçlarına öncelik vermek olarak planlanmıştır. Kazı raporlarına, tasnif ve tanıma dayalı çalışmalara, buluntu katalogları ve özgün olmayan derleme yazılarına öncelik verilmeyecektir.

Arkeoloji Bilimleri Dergisi açık erişimli, uluslararası hakemli bir dergidir. Araştırma ve yayın etiğine uygun bulunan makaleler çift taraflı kör hakem değerlendirme sürecinden geçtikten sonra yayınlanır. Dergi, Ege Yayınları tarafından çevrimiçi olarak yayınlanmaktadır.

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ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Aims & Scope

Archaeology is being transformed by integrating innovative methodologies and scientific analyses into archaeological research. With new departments, institutes, and programs focusing on "Archaeological Sciences", archaeology has moved beyond the traditional approaches of the discipline. When placed within their archaeological context, scientific analyses can provide novel insights and new interpretive perspectives to study archaeological materials, settlements and landscapes.

In Türkiye, the number of interdisciplinary excavation and research projects incorporating scientific techniques is on the rise. A growing number of researchers are being trained in a broad range of scientific fields, including but not limited to archaeobotany, archaeozoology, tool technologies, dating methods, micromorphology, bioarchaeology, geochemical and spectroscopic analysis, Geographical Information Systems, and climate and environmental modeling. The Turkish Journal of Archaeological Sciences (TJAS) aims to situate Turkish archaeology within this new paradigm and to diversify and disseminate scientific research in archaeology. New methods, analytical techniques and interdisciplinary initiatives that contribute to archaeological interpretations and theoretical perspectives fall within the scope of the journal. Excavation reports and manuscripts focusing on the description, classification, and cataloging of finds do not fall within the scope of the journal.

The Turkish Journal of Archaeological Sciences is an open access, international, double-blind peer-reviewed yearly publication. Articles that comply with publication and research ethics are published after the reviewing process. The journal is published online by Ege Yayınları in Türkiye.

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ARKEOLOJİ
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Makale Değerlendirme Politikası (Çift Taraflı Kör Hakemlik) ve Yayın Süreci

Arkeoloji Bilimleri Dergisi, Türkçe veya İngilizce özgün araştırma makaleleri yayımlamaktadır.

1. Daha önce yayımlanmamış veya başka bir dergide değerlendirme sürecinde bulunmayan ve tüm yazarlar tarafından onaylanan makaleler değerlendirilmek üzere kabul edilir.
2. Gönderilen makaleler, ön inceleme, intihal taraması, hakem değerlendirmesi ve dil düzenlemesi aşamalarından geçirilir.
3. Ön inceleme aşamasını geçemeyen makaleler, yazar(lar)a iade edilir ve aynı yayın döneminde tekrar değerlendirmeye alınmaz. Ön incelemeyi geçen makaleler, en az iki hakemin değerlendirdiği çift taraflı kör hakem sürecine tabi tutulur.
4. İntihal kontrolünden geçen makaleler, Editör tarafından bilimsel içerik, yöntem, ele alınan konunun önemi ve derginin kapsamına uygunluk açısından değerlendirilir. Editör, makalelerin ön değerlendirmesini yapmak üzere editör yardımcılarına yönlendirir.
5. Editör yardımcıları, her bir makaleyi son gönderim tarihinden önce inceleyerek Arkeoloji Bilimleri Dergisi yayın ilkelerine uygunluğunu değerlendirir. Bu aşamada intihal taraması yapılır ve dergi yazım kurallarına uygunluk kontrol edilir.
6. Editörler ve editör yardımcıları, makalenin etik standartlara, konuya uygunluğa, metin düzenine, dipnotlar ve kaynakçaya, görsel kalitesine ve gerekli telif hakkı izinlerine uyup uymadığını değerlendirir. Bu kriterleri karşılayan makaleler, çift taraflı kör hakemlik süreci korunarak en az iki ulusal/uluslararası hakeme gönderilir.
7. Derginin hakem değerlendirme süreci ve editoryal etik kuralları, değerlendirmelerin milliyet, cinsiyet veya diğer herhangi bir faktöre dayalı önyargılardan arındırılmış olmasını sağlar. Makaleler, doktora derecesine sahip ve güçlü bir araştırma geçmişi bulunan en az iki uzman tarafından değerlendirilir.

8. Hakemler, makalenin yayınlanmaya uygunluğunu değerlendiren bir form doldurur ve gerekli revizyonlara yönelik önerilerde bulunur. Hakemler makaleyi değişiklik yapmadan kabul edebilir, küçük değişikliklerle kabul edebilir, büyük değişiklikler ve yeniden gönderim talep edebilir veya makaleyi reddedebilir. Her iki hakem de küçük değişiklikleri kabul ederse ve revize edilen versiyon onaylanırsa makale kabul edilir. Büyük değişiklikler gerektiğinde, makale Editörler tarafından yeniden değerlendirilir ve gerekli düzeltmeler yapıldıktan sonra hakemlere geri gönderilebilir. Revizyonlar yeterli bulunduğunda makale yayımlanmak üzere kabul edilir. Eğer bir hakem makaleyi reddeder veya biri olumlu, diğeri olumsuz görüş bildirirse, makale üçüncü bir hakeme gönderilir. Ancak iki hakemin olumlu görüş bildirmesi durumunda, son yayın kararı Editör Kurulu tarafından verilir. Editoryal kararlar nihaidir ve yalnızca istisnai durumlarda ilgili COPE yönergelerine göre itiraz edilebilir.
9. Hakemlerden, değerlendirmelerinde nazik, saygılı ve bilimsel bir dil kullanmaları beklenir. Saldırgan, saygısız veya kişisel yorumlardan kaçınmaları gerekmektedir. Bilimsel olmayan yorumlar tespit edildiğinde, dergi yönetimi hakemden raporunu gözden geçirmesini ve düzeltmesini talep eder. Hakemlerin değerlendirmelerini belirtilen süre içinde tamamlaması ve burada açıklanan etik sorumluluklara uyması gerekmektedir.
10. Dil düzenlemesi tamamlandıktan sonra, kabul edilen makaleler ilgili dergi sayısında tematik veya kronolojik sıraya göre düzenlenir.
11. Makalelerin mizanpajı, dergi tasarımına uygun olarak yapılır ve ardından Editörler tarafından gözden geçirilir.
12. Makalelerin son PDF versiyonu, nihai kontrol ve onay için yazarlara gönderilir. Yazarlar, makalenin derginin etik standartlarına uygun olduğunu ve çalışmalarının tüm sorumluluğunu kabul ettiklerini teyit etmelidir.
13. Hakemlerin talepleri doğrultusunda yazarlar tarafından yapılan düzenlemeler incelendikten sonra, nihai yayın kararı Yayın Kurulu tarafından verilir.
14. Yukarıda belirtilen süreçler tamamlandıktan sonra ilgili dergi sayısı son haline getirilir ve makalelere DOI numaraları atanır.
15. DOI numaraları atandıktan sonra baskı süreci başlar ve yayın süreci tamamlanır.

Editör Sorumlulukları

1. Editör, makaleleri yalnızca bilimsel içerik temelinde değerlendirir; yazarların etnik kökeni, cinsiyeti, cinsel yönelimi, milliyeti, dini inançları veya siyasi görüşleri dikkate alınmaz.
2. Editör, gönderilen makalelerin tarafsız bir şekilde çift taraflı kör hakem değerlendirmesine tabi tutulmasını sağlar ve yayınlanmadan önce gizliliği korur.

3. Editör, hakemlere makalelerin gizli bilgi içerdiğini ve değerlendirmenin ayrıcalıklı bir etkileşim olduğunu bildirir. Hakemler ve yayın kurulu üyeleri, makaleleri üçüncü şahıslarla tartışamaz. Belirli durumlarda, Editör belirli bir noktayı netleştirmek amacıyla bir hakemin değerlendirmesini diğer hakemlerle paylaşabilir.
4. Editör, derginin içeriği ve genel kalitesinden sorumludur; gerektiğinde düzeltme notu yayımlamak veya geri çekme işlemi yapmak editörün sorumlulukları arasındadır.
5. Editör, yazarlar, editörler ve hakemler arasında çıkar çatışmasına izin vermez. Hakem atama konusunda tam yetkilidir ve makalelerin yayımlanmasına ilişkin nihai karardan sorumludur.

Hakem Sorumlulukları

1. Hakemler, araştırma, yazarlar ve/veya finansman sağlayıcıları ile herhangi bir çıkar çatışması içinde olmamalıdır. Değerlendirmeleri objektif olmalıdır.
2. Hakemler, gönderilen makalelerle ilgili tüm bilgilerin gizli kalmasını sağlamalı ve telif hakkı ihlali veya intihal tespit etmeleri durumunda Editöre bildirmelidir.
3. Kendini makaleyi değerlendirmede yetersiz hisseden veya incelemeyi belirtilen süre içinde tamamlayamayacağı kanısına varan hakem, Editöre haber vermeli ve değerlendirme sürecinden çekilmelidir.

Yazar Sorumlulukları

1. Yazar olarak belirtilen kişiler, makalenin kavramsallaştırılması, tasarımı, veri toplama ve yorumlama, veri analizi veya araştırma ve yazım süreçlerine önemli katkıda bulunmuş olmalıdır. Tüm ortak yazarlar, makalenin son sürümünü onaylamalı ve içeriğinden eşit derecede sorumlu olmalıdır.
2. Yazarlar, görsellerin (fotoğraf veya şekiller) telif hakkı düzenlemelerine uygun olmasını sağlamalı veya gerekli izinleri almalıdır. Eğer etik veya telif hakkı ihlali tespit edilirse, dergi ilgili makaleyi geri çekme veya erişimini engelleme hakkını saklı tutar.
3. Yazarlar, dergi editörleri ile iletişim kurmaktan, düzeltmeleri yapmaktan, makaleyi belirtilen sürede yeniden göndermekten ve etik ile telif hakkı kurallarına uygunluğu onaylamaktan sorumludur. İlk gönderimden sonra yazar isim değişiklikleri dikkate alınmaz.

Düzeltme Süreci

Hakemler tarafından revizyon talep edilmesi durumunda, ilgili raporlar yazara iletilir ve yazarın en kısa sürede gerekli düzeltmeleri yapması beklenir. Yazar, yaptığı düzeltmeleri işaretleyerek güncellenmiş makaleyi Editörlere sunmalıdır.

Türkçe Dil Düzenlemesi: Hakem sürecinden geçen Türkçe makaleler, Türkçe Dil Editörü tarafından incelenir ve gerekli görüldüğünde yazardan tashih istenebilir.

Yabancı Dil Düzenlemesi: Hakem sürecinden geçen İngilizce makaleler, Yabancı Dil Editörü tarafından gözden geçirilir ve gerekli görüldüğünde yazardan ek düzeltmeler yapması istenebilir.

Dizgi, Mizanpaj ve Son Okuma Süreci

Yayın Kurulu tarafından yayımlanması onaylanan makaleler, nihai yayına hazırlanmak üzere dizgi ve mizanpaj işlemlerine tabi tutulur. Mizanpaj işlemi tamamlandıktan sonra, yayınlanmadan önce makaleler için son okuma süreci gerçekleştirilir.

DOI Atama

Dijital Nesne Tanımlayıcısı (DOI), elektronik ortamda yayımlanan bir makalenin resmi ve orijinal versiyonuna kalıcı bir bağlantı sağlayan benzersiz bir kimlik numarasıdır. Arkeoloji Bilimleri Dergisi, yayın sürecinin tamamlanmasının ardından kabul edilen tüm bilimsel makalelere DOI numarası atayarak, makalenin dijital ortamda resmi kaydını güvence altına alır.

ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Article Evaluation Policy (Double-Blind Peer Review) and Publication Process

The Turkish Journal of Archaeological Sciences publishes original research articles in Turkish or English.

1. Manuscripts must be original, unpublished, and not under review elsewhere. All authors must approve the submission.
2. Submitted manuscripts undergo preliminary review, plagiarism screening, peer review, and language editing.
3. Manuscripts that do not pass the preliminary review are returned to the author(s) and are not reconsidered within the same publication period. Those that pass proceed to the double-blind peer review, evaluated by at least two reviewers.
4. The Editors evaluate manuscripts based on scientific content, methodology, significance, and the journal scope. Manuscripts passing this stage are assigned to associate editors for preliminary assessment.
5. Associate editors ensure manuscripts comply with journal principles, including plagiarism screening and adherence to formatting guidelines.
6. Editors and associate editors verify compliance with ethical standards, subject relevance, formatting, references, image quality, and copyright permissions. Approved manuscripts are sent for double-blind peer review.
7. The journal's peer review process maintains fairness and objectivity, free from biases based on nationality, gender, or other factors. Reviewers must have a doctoral degree and a strong research background.
8. The reviewers complete evaluation forms and provide recommendations: accept without changes, accept with minor revisions, request major revisions and resubmission, or reject. If both reviewers recommend minor revisions, and the revised version is approved, the

manuscript is accepted. If major revisions are required, the manuscript may be reassessed before final decision. If there is one positive and one negative review, a third reviewer is consulted. The final decision rests with the Editors. Editorial decisions are final and can only be appealed under COPE guidelines.

9. Reviewers must use respectful, professional, and scientific language. Disrespectful or unscientific comments will prompt a revision request. Reviews must be completed within the assigned timeframe.
10. After final editing, accepted manuscripts undergo thematic or chronological organization before inclusion in the journal.
11. Typesetting is conducted according to journal layout guidelines.
12. The final PDF version is sent to the authors for review and approval. Authors must confirm that the manuscript adheres to the journal's ethical standards and accept full responsibility for their work.
13. The Editorial Board makes the final publication decision after reviewing revisions.
14. Once this process is finalized, DOI numbers are assigned to the articles.
15. Following DOI assignment, the printing stage begins, completing the publication process.

Editor Responsibilities

1. The Editor evaluates manuscripts based solely on scientific merit, without bias toward authors' ethnicity, gender, nationality, or beliefs.
2. The Editor ensures a fair, confidential double-blind peer review process.
3. Manuscripts remain confidential before publication. Reviewers and editorial board members must not discuss them with third parties. If necessary, reviewer evaluations may be shared between reviewers by the Editor for clarification.
4. The Editor ensures journal quality, including corrections and retractions when necessary.
5. The Editor prevents conflicts of interest and has full authority in reviewer assignments and publication decisions.

Reviewer Responsibilities

1. Reviewers must disclose any conflicts of interest regarding the research, authors, or funding sources. Reviews must be objective.
2. Reviewers must maintain confidentiality and report any copyright infringement or plagiarism to the Editor.
3. Reviewers who feel unqualified to evaluate a manuscript or unable to complete their evaluation on time should notify the Editor and withdraw.

Author Responsibilities

1. All authors must have made significant contributions to the manuscript in terms of conceptualization, design, data collection and interpretation, data analysis, or research and writing. All co-authors must approve the final version and share responsibility for its content.
2. Authors must ensure that all images comply with copyright regulations or obtain necessary permissions. The journal reserves the right to retract or restrict access to articles with unresolved copyright or ethical issues. Any such actions will follow COPE guidelines.
3. The corresponding author is responsible for journal communication, revisions, post-publication inquiries, and compliance with the journal's ethical and copyright policies. Changes to authorship after submission will not be considered.

Revision Process

If revisions are requested, the review reports are sent to the authors. The authors must make necessary revisions promptly, highlighting them for clarity, and submit the updated manuscript to the Editors.

Turkish Language Editing: Turkish manuscripts passing peer review are reviewed by the Turkish Language Editor, who may request corrections.

Foreign Language Editing: English manuscripts passing peer review are reviewed by the English Language Editor, who may request corrections.

Typesetting, Layout, and Proofreading Process

Approved manuscripts undergo typesetting and layout formatting, followed by a final proofreading before final publication.

DOI Assignment

Digital Object Identifier (DOI) is a unique identifier that provides a permanent link to the official and original version of an electronically published article. The Turkish Journal of Archaeological Sciences assigns DOI numbers to all accepted scientific articles at the end of the publication process, ensuring the article's official recording in the digital environment.

ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Arkeoloji Bilimleri Dergisi Yayın Etiği ve Yayın Politikası

Yayın Etiği

Arkeoloji Bilimleri Dergisi, yürütülen tüm süreçlerde; Yazar, Hakem, Editör, Yayıncı ve Okuyucu sorumlulukları bağlamında yayın etiğine ilişkin uluslararası bir standart olarak kabul gören *Committee on Publication Ethics* (COPE) politikalarını benimsemekte ve yönergelerini takip etmektedir.

Editörler için: Editörler kurulunda yer alan araştırmacıların göndermiş olduğu makalelerle ilgili olarak makale hakem sürecindeyken makale sahibi editörlerin editör rolleri askıya alınır ve hakem sürecini görmemeleri sağlanır, böylece çift taraflı kör hakemlik korunur.

Hakemler için: Arkeoloji Bilimleri Dergisi, önyargısız ve en iyi etik standartlara göre çift taraflı kör hakem değerlendirmesi sistemi işletir ve COPE'nin Akran Hakemleri için Etik İlkelerinde belirtilen akran hakemlerine yönelik kılavuzunu dikkate alır. Hakemlerin, incelemelerini kendilerine ayrılan süre içinde tamamlamaları beklenir. Hakemlerimizin gizliliğine saygı duyuyor, yazarların ve hakemlerin de aynı gizliliğe uymasını bekliyoruz. Hakemlerin önyargısız ve saygılı bir dil kullanarak rapor vermeleri beklenir. Agresif dil veya yazarlar hakkında kişisel görüşler içeren yorumlar dikkate alınmaz. Bir hakem, gönderiyi incelemeye başlamadan önce varsa konuya istinaden veya olası herhangi bir çıkar çatışması hakkında editörleri bilgilendirmelidir.

Yazarlar için: Arkeoloji Bilimleri Dergisi, bilim dünyasına özgün çalışmalar sunmayı amaçlamaktadır. Makaleler özgün bilimsel araştırma olmalıdır. Dergiye çalışmalarını gönderen yazar(lar) söz konusu yazının daha önce başka bir yerde yayımlanmadığını ya da yayımlanmak üzere bir başka yere gönderilmemiş olduğunu kabul etmiş sayılırlar. Yazarlar, araştırma ve yayın etiğine uyduklarını kabul ederler. Yazar/lar etik izin gerektiren çalışmalar için Etik Kurul İzni sunmalıdır. Yazar/lar araştırma sürecinde araştırmaları için mali destek almışlarsa bu desteği makale metninde belirtmelidir. Yayın sonrası hata tespit edilmesi durumunda yazar/lar, hatalı makaleyi geri çekmek ve düzeltmekle yükümlüdür. Dergi ilkelerine uymayan makaleler dergiye kabul edilmezler. Ön değerlendirme ve intihal denetimini başarıyla geçen makaleler hakem değerlendirme süreci için en az iki hakeme gönderilir.

Telif Hakkı

Arkeoloji Bilimleri Dergisi'nde yayımlanan tüm özgün makaleler, Creative Commons Atıf-Gayri Ticari 4.0 International (*CC BY-NC 4.0*) lisansına tabidir. Bu lisans ile taraflar, Arkeoloji Bilimleri Dergisi'nde yayımlanan tüm makaleleri ve görselleri; atıfta bulunarak dağıtabilir, kopyalayabilir, üzerine çalışma yapabilir, yine sahibine atıfta bulunarak türevi çalışmalar yapabilir. Arkeoloji Bilimleri Dergisi tarafından yayınlanan makalelerin telif hakları CC BY-NC 4.0 lisansı kapsamında yazarlara aittir. Yayınlanan tüm telif hakları yazarın/yazarların sorumluluğundadır. Dergide yayınlamayı kabul ederek, yazarlar bu telif hakkı şartlarına uymayı da kabul ederler. Dergide yayımlanan eserlerin sorumluluğu yazarlarına aittir. Yazarların yayımlanmış olan makalelerine ait PDF dosyaları, kendi kurumsal arşivleri ile başka makale platformlarında ve sosyal medya hesaplarında açık erişim politikası gereği paylaşılabilir. Arkeoloji Bilimleri Dergisi hiçbir çıkar gözetmez.

İntihal

Arkeoloji Bilimleri Dergisi, intihal tespit yazılımı (*iThenticate* veya benzeri) kullanarak metinleri kontrol etme hakkını saklı tutar. İntihal, başkalarına ait çalışmaların (fikirlerin, verilerin, kelimelerin, görüntülerin vb. her türlü medyatik formun) kaynak göstermeden veya gerekli olduğunda izin veya onay alınmadan kullanılmasıdır. Bu tanım çerçevesinde yazar(lar)ın gerekli referanslar veya izinler olmadan kendi çalışmalarını yeniden üretmeleri, kendinden kendine intihali içerir. İntihal materyali içeren gönderiler otomatik olarak reddedilecektir. Yayınlanmış ise yayınlandıktan sonra dahi, ilgili eyleme karar verilerek COPE'nin Akran Hakemleri için Etik İlkelerine göre sürdürülür.

Makale Geri Çekme Politikası

Bünyesinde özgün makalelere yer veren Arkeoloji Bilimleri Dergisi yayın yönetimi, yayın politikası gereği henüz değerlendirme aşamasında veya dergide yayımlanmış bir makaleye dair etik olmayan bir durum şüphesinin oluşması veya telif hakkı ihlali halinde, söz konusu çalışma hakkında incelemelerde bulunabilir. Yapılan incelemeler sonucunda bu amaçla değerlendirilen makale için COPE'nin makale geri çekme süreçleri uygulanır.

Eğer dergi editörleriyle iletişime geçen çalışma sahibinin kendisinden henüz yayımlanmış, hakem sürecinden geçerek kabul edilmiş ya da değerlendirme aşamasındaki çalışmalarıyla ilgili bir geri çekme talebi gelirse Arkeoloji Bilimleri Dergisi Yayın Kurulu bunu ivedilikle işleme alır. Bu işlemin yapılabilmesi için yazar(lar)ın geri çekme isteklerini kaleme aldıkları bir belge hazırlayıp her bir yazarın ıslak imzasıyla imzalayarak Arkeoloji Bilimleri Dergisi e-posta adresine (editor@arkeolojibilimleridergisi.org) iletmesi gereklidir. Bu süreç COPE'nin Akran Hakemleri için Etik İlkelerine göre sürdürülür. Arkeoloji Bilimleri Dergisi Yayın Kurulu, başvuruyu inceleyip karar vermeden önce yazarların çalışmasını başka bir dergiye yayınlanmak üzere göndermesini katiyetle etik bir davranış olarak kabul görmez.

Finansman

Yayında sunulan çalışmanın tamamlanması için alınan fon ve benzeri araştırma desteği, uygun olduğunda hibe numaraları ve/veya bilimsel proje numaraları da dahil olmak üzere beyan edilmelidir. Arkeoloji Bilimleri Dergisi'nde uygulanan yayın süreçleri, bilginin tarafsız ve saygın bir şekilde gelişimine ve dağıtımına temel oluşturmaktadır. Hakemli çalışmalar bilimsel yöntemi somutlaştıran ve destekleyen çalışmalardır. Bu noktada sürecin bütün paydaşlarının—yazarlar, okuyucular ve araştırmacılar, yayıncı, hakemler ve editörler—etik ilkelere yönelik standartlara uyması önem taşımaktadır. Makalelerde cinsiyetçi, ırkçı veya kültürel ayrım yapmayan, kapsayıcı bir dil kullanmalıdır ("insanoğlu" yerine "insan"; "bilim adamı" yerine "bilim insanı" gibi). Arkeoloji Bilimleri Dergisi yayın etiği kapsamında tüm paydaşların bu etik sorumlulukları taşımasını beklenmektedir. Burada belirtilen etik görev ve sorumluluklar, Committee on Publication Ethics (COPE) tarafından açık erişimli olarak yayınlanan rehberler ve politikalar dikkate alınarak hazırlanmıştır. Bkz.: COPE İş Akış Diyagramları.

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Arkeoloji Bilimleri Dergisi'nde değerlendirilen çalışmalarda gerçek kişilere ait kişisel veriler Kişisel Verilerin Korunması Hakkında Kanun kapsamında koruma altındadır. Yazara ait hiçbir bilgi üçüncü kişi ve kurumlarla paylaşılmaz.

ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Turkish Journal of Archaeological Sciences Publication Ethics and Policies

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Funding Disclosure

If the research was supported by a grant or other financial resources, authors must disclose this in the manuscript, including relevant grant numbers and project identifiers where applicable.

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ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Makale Gönderimi ve Yazım Kılavuzu

* *Please see below for English*

Makale Kabul Kriterleri

Makalelerin konu aldığı çalışmalar, Arkeoloji Bilimleri Dergisi'nin amaçları ve kapsamı ile uyumlu olmalıdır (bkz.: Amaç ve Kapsam).

Makaleler Türkçe veya İngilizce olarak yazılmalıdır. Makalelerin yayın diline çevirisi yazar(lar)ın sorumluluğundadır. Eğer yazar(lar) makale dilinde akıcı değilse, metin gönderilmeden önce anadili Türkçe ya da İngilizce olan kişilerce kontrol edilmelidir.

Her makaleye 200 kelimeyi aşmayacak uzunlukta Türkçe ve İngilizce yazılmış özet ve beş anahtar kelime eklenmelidir. Özete referans eklenmemelidir.

Yazarın Türkçesi veya İngilizcesi akıcı değilse, özet ve anahtar kelimelerin Türkçe veya İngilizce çevirisi editör kurulu tarafından üstlenilebilir.

Metin, figürler ve diğer dosyalar wetransfer veya e-posta yoluyla **archaeologicalsciences@gmail.com** adresine gönderilmelidir.

Makale Kontrol Listesi

Lütfen makalenizin aşağıdaki bilgileri içerdiğinden emin olun:

- Yazarlar (yazarların adı-soyadı ve iletişim bilgileri buradaki sırayla makale başlığının hemen altında paylaşılmalıdır)
- Çalışılan kurum (varsa)
- E-mail adresi
- ORCID ID

Makalenin içermesi gerekenler:

- Başlık
- Özet (Türkçe ve İngilizce)
- Anahtar kelimeler
- Metin
- Kaynakça
- Figürler
- Tablolar

Yazım Kuralları

Metin ve Başlıkların Yazımı

- Times New Roman karakterinde yazılan metin 12 punto büyüklüğünde, iki yana yaslı ve tek satır aralıklı yazılmalıdır. Makale word formatında gönderilmelidir.
- Yabancı ve eski dillerdeki kelimeler *italik* olmalıdır.
- Başlık ve alt başlıklar **bold** yazılmalıdır.
- Başlıklar numaralandırılmamalı, italik yapılmamalı, altları çizilmemelidir.
- Başlık ve alt başlıklarda yalnızca her kelimenin ilk harfi büyük olmalıdır.

Referans Yazımı

Ayrıca bkz.: Metin içi Atıflar ve Kaynakça Yazımı

- Referanslar metin içinde (Yazar yıl, sayfa numarası) şeklinde verilmelidir.
- Referanslar için dipnot ve son not kullanımından kaçınılmalıdır. Bir konuda not düşme amacıyla gerektiği taktirde dipnot tercih edilmelidir.
- Dipnotlar Times New Roman karakterinde, 10 punto büyüklüğünde, iki yana yaslı, tek satır aralıklı yazılmalı ve her sayfa sonuna süreklilik izleyecek şekilde eklenmelidir.

Şekiller ve Tablolar

- Makalenin altına şekiller ve tablolar için bir başlık listesi eklenmelidir. Görsellerde gerektiği taktirde kaynak belirtilmelidir. Her şekil ve tabloya metin içerisinde gönderme yapılmalıdır (Şekil 1 veya Tablo 1).
- Görseller Word dokümanının içerisine yerleştirilmemeli, jpg veya tiff formatında, ayrı olarak gönderilmelidir.
- Görüntü çözünürlüğü basılması istenen boyutta ve 300 dpi'nin üzerinde olmalıdır.
- Görseller Photoshop ve benzeri programlar ile müdahale edilmeden olabildiğince ham haliyle gönderilmelidir.
- Excel'de hazırlanmış tablolar ve grafikler var ise mutlaka bunların PDF ve Excel dokümanları gönderilmelidir.

Tarihlerin ve Sayıların Yazımı

- MÖ ve MS kısaltmalarını harflerin arasına nokta koymadan kullanınız (örn.: M.Ö. yerine MÖ).
- "Bin yıl" ya da "bin yıl" yerine "... binyıl" kullanınız (örn.: MÖ 9.binyıl).
- "Yüzyıl", "yüz yıl" ya da "yy" yerine "yüzyıl" kullanınız (örn.: MÖ 7.yüzyıl).
- Beş veya daha fazla basamaklı tarihler için sondan sayarak üçlü gruplara ayırmak suretiyle sayı gruplarının arasına nokta koyunuz (örn.: MÖ 10.500).
- Dört veya daha az basamaklı tarihlerde nokta kullanmayınız (örn.: MÖ 8700).
- 0-10 arasındaki sayıları rakamla değil yazıyla yazınız (örn.: "8 kez yenilenmiş taban" yerine "sekiz kez yenilenmiş taban").

Noktalama ve İşaret Kullanımı

- Ara cümleleri lütfen iki çizgi ile ayırınız (—). Çizgi öncesi ve sonrasında boşluk bırakmayınız.
- Sayfa numaraları, tarih ve yer aralıklarını lütfen tek çizgi (-) ile ayırınız: 1989-2006; İstanbul-Kütahya.

Kısaltmaların Yazımı

- Sık kullanılan bazı kısaltmalar için bkz.:

Yaklaşık:	yak.	Circa:	ca.
Bakınız:	bkz.	Kalibre:	kal.
Örneğin:	örn.	ve diğerleri:	vd.

Özel Fontlar

- Makalede özel bir font kullanıldıysa (Yunanca, Arapça, hiyeroglif vb.) bu font ve orijinal metnin PDF versiyonu da gönderilen dosyalar içerisine eklenmelidir.

Metin içi Atıflar ve Kaynakça Yazımı

Her makale, metin içinde atıfta bulunulan çalışmalardan oluşan ve "Kaynakça" başlığı altında düzenlenmiş APA7'ye göre bir referans listesi içermelidir. Metin içindeki her referansın kaynakçada yer aldığından emin olunuz.

https://apastyle.apa.org/style-grammar-guidelines/references/examples

- **Doğrudan atıf:** *Örnek:* "… Esin (1995)'in belirtmiş olduğu gibi."
- **Parantez içinde atıf:** *Örnek:* "… analiz sonuçları gösteriyor ki … (Esin, 1995)."
- **Aynı parantezde birden fazla atıf: Yayın yılına** göre sıralanmalı ve noktalı virgül ile ayrılmalıdır. *Örnek:* "… (Dinçol & Kantman, 1969; Esin, 1995; Özbal et al., 2004)."
- **Aynı yazarın farklı yıllara ait yayınlarına atıf:** Yazarın soyadı bir kez kullanılır, yıllar virgül ile ayrılır. *Örnek:* "… (Peterson, 2002, 2010)."
- **Aynı yazarın aynı yıl içindeki farklı yayınlarına atıf:** Yılın yanına alfabetik harf eklenir (örn. "a", "b"). *Örnek:* "… (Peterson, 2010a, 2010b)."
- **Tek yazarlı ve çok yazarlı kaynaklar:** Tek yazarlı kaynaklar önce sıralanır. Aynı yazarın farklı eş yazarlara sahip kaynakları ikinci yazarın soyadına göre alfabetik sıralanır. *Örnek:* "… (Esin, 1995; Esin & Özbal, 1998)."
- **Kaynakça Yazım Kuralları:** Kaynakça, ilk yazarın soyadına göre **alfabetik** olarak sıralanmalı ve aşağıdaki kurallar izlenmelidir:
  1) **Tek yazarlı yayınlar:** Yazarın soyadına göre sıralayın, ardından yayın yılına göre (en eskiden en yeniye doğru) düzenleyin.
  2) **İki yazarlı yayınlar:** İlk yazarın soyadına göre sıralayın, ardından ikinci yazarın soyadına göre ve son olarak yayın yılına göre sıralayın.
  3) **Üç veya daha fazla yazarlı yayınlar:** İlk yazarın soyadına göre sıralayın, ardından yayın yılına göre (en eskiden en yeniye doğru) düzenleyin. Ek yazarların sırası önemli değildir.

- Metinde atıfta bulunulan tüm çalışmalar "Kaynakça" başlığı altında listelenmelidir.
- Eğer mevcutsa, dergi makaleleri için mutlaka DOI numarası eklenmelidir (örn. "*https://doi.org/abc*").
- Kişisel iletişimler ve yayımlanmamış çalışmalar yalnızca metin içinde belirtilmelidir ve kaynakçaya eklenmemelidir.

Dergi makalesi

Bickle, P. (2020). Thinking gender differently: New approaches to identity difference in the Central European Neolithic. *Cambridge Archaeological Journal, 30*(2), 201–218. https://doi.org/10.1017/S0959774319000453

Hansen, S., Mirtskhulava, G., & Bastert-Lamprichs, K. (2007). Aruchlo: A Neolithic settlement mound in the Caucasus. *Neo-Lithics*, *1*, 13–19.

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Metin içi atıf: (Hansen vd., 2007; Pearson & Meskell, 2015; Bickle, 2020). Eğer sayfa numarası eklenecek ise: (Hansel vd., 2007, 16; Pearson & Meskell, 2015, 475; Bickle, 2020, 210–212).

Kitap / e-kitap

Dinçol, A. M., & Kantman, S. (1969). *Analitik arkeoloji: Denemeler.* Edebiyat Fakültesi Basımevi.

Peterson, J. (2002). *Sexual revolutions: Gender and labor at the dawn of agriculture.* AltaMira Press.

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Akkermans, P. M. M. G., & Schwartz, G. M. (Eds.). (2003). *The archaeology of Syria: From complex hunter-gatherers to early urban societies (c. 16,000–300 BC)*. Cambridge University Press.

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Özkaya, V., & San, O. (2007). Körtik Tepe: Initial observations on cultural context based on findings. In M. Özdoğan & N. Başgelen (Eds.), *The Neolithic period in Turkey: New excavations and findings* (pp. 21–36). Archaeology and Art Publications.

Metin içi atıf: (Esin, 1995; Akkermans & Schwartz, 2003; Özkaya & San, 2007)

Çeviri kitabı

Foucault, M. ([1954]1992). Deliliğin tarihi. (M. A. Kılıçbay, Çev.). İmge Kitapevi.

Metin içi atıf: (Foucault, 1992)

Yüksek lisans & Doktora tezi

Kayacan, N. (2015). Anadolu'da Neolitik Dönem'de baskı tekniği ile taş yongalama: Uygulama, dağılım ve kültürel farklılıklar [Yayımlanmamış Doktora Tezi]. İstanbul Üniversitesi.

Metin içi atıf: (Kayacan, 2015)

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TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Submission and Style Guideline

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Each manuscript should include a Turkish and an English abstract of up to 200 words and five keywords in both Turkish and English. Citations should not be included in the abstract.

If the author(s) are not fluent in the language of the manuscript, a translation of the abstract and the keywords may be provided by the editorial board.

Manuscripts, figures, and other files should be sent via wetransfer or e-mail to **archaeologicalsciences@gmail.com** .

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Each article must contain the following:

- Authors (please provide the name-last name and contact details of each author under the main title of the manuscript)
- Affiliation (where applicable)
- E-mail address
- ORCID ID

The manuscript should contain:

- Title
- Abstract (in English and Turkish)
- Keywords
- Text
- References
- Figures (when applicable)
- Tables (when applicable)

Style Guide

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- Manuscripts should be written in Times New Roman 12-point font, justified and single-spaced. Please submit the manuscript as a word document.
- Words in foreign and ancient languages should be *italicized*.
- Titles and subtitles should appear in **bold**.
- Titles and subtitles should not be numbered, italicized, or underlined.
- Only the first letter of each word in titles and subtitles should be capitalized.

References

Cf.: In-Text Citations and References

- In-text citations should appear inside parenthesis (Author, year, page number).
- Footnotes and endnotes should not be used for references. Comments should be included in footnotes rather than endnotes.
- The footnotes should be written in Times New Roman 10-point font, justified and single-spaced, and should be continuous at the bottom of each page.

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- Please provide a caption list for figures and tables following the references. Provide credits where applicable. Each figure and table should be referenced in the text (Figure 1, or Table 1), but please do not include figures in the text document.
- Each figure should be submitted separately as a jpg or tiff file.
- Images should be submitted in the dimensions in which they should appear in the published text and their resolution must be over 300 dpi.
- Please avoid editing the figures in Photoshop or similar programs but send the raw version of the figures if possible.
- Tables and graphs prepared in Excel should be sent as both PDF and Excel documents.

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- Please use BCE/CE and please avoid using dots without dots (i.e., BCE instead of BC or B.C.).
- Please use a dot for numbers and dates with 5 or more digits (i.e., 10.500 BCE).
- Please avoid using dots for numbers and dates with 4 or less digits (i.e., 8700 BCE).
- Please spell out whole numbers from 0 to 10 (e.g., “the floor was renewed eight times” instead of “the floor was renewed 8 times”).

Punctuation

- Please prefer em dashes (—) for parenthetical sentences: “Children were buried with various items, the adolescents—individuals between the ages of 12-19—had the most variety in terms of grave goods.”
- Please prefer an en dash (-) between page numbers, years, and places: 1989-2006; İstanbul-Kütahya.

Abbreviations

- Commonly used abbreviations:

Approximately:	approx.	Figure:	Fig.
Confer:	cf.	*Id est:*	i.e.
Circa:	ca.	*Exempli gratia:*	e.g.
Calibrated:	cal.		

Special Fonts

- If a special font must be used in the text (e.g., Greek or Arabic alphabet or hieroglyphs), the text in the special font and the original manuscript should be sent in separate PDF files.

In-Text Citations and References

Each article must include a reference list titled "References," containing only works cited in the text, formatted according to APA 7. Ensure that every in-text citation has a corresponding entry in the reference list.

https://apastyle.apa.org/style-grammar-guidelines/references/examples

- **Direct Citation:** *Example:* "As Esin (1995) stated…"
- **Parenthetical Citation:** *Example:* "The analysis results indicate… (Esin, 1995)."
- **Multiple Citation in One Parenthesis:** Arrange by **publication year** and separate with semicolons. *Example:* "(Dinçol & Kantman, 1969; Esin, 1995; Özbal et al., 2004)."
- **Publications by the Same Author in Different Years:** List the author once and separate publication years with commas. *Example:* "(Peterson, 2002, 2010)."
- **Multiple Publications by the Same Author in the Same Year:** Add letters alphabetically to the publication year (e.g., "a," "b"). *Example:* "(Peterson, 2010a, 2010b)."
- **Single and Multiple Authors:** List single-author works before multi-author works. For works by the same first author with different co-authors, arrange alphabetically by the second author's last name. *Example:* "(Esin, 1995; Esin & Özbal, 1998)."
- **Reference List Formatting:** References should be arranged **alphabetically** by the last name of the first author, following these rules:
  1) **Single-author publications:** Order by the author's last name, then by publication year (earliest to latest).
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Journal article

Bickle, P. (2020). Thinking gender differently: New approaches to identity difference in the Central European Neolithic. *Cambridge Archaeological Journal, 30*(2), 201–218. https://doi.org/10.1017/S0959774319000453

Hansen, S., Mirtskhulava, G., & Bastert-Lamprichs, K. (2007). Aruchlo: A Neolithic settlement mound in the Caucasus. *Neo-Lithics*, *1*, 13–19.

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In-text citation: (Hansen et al., 2007; Pearson & Meskell, 2015; Bickle, 2020). If page numbers are required: (Hansel et al., 2007, 16; Pearson & Meskell, 2015, 475; Bickle, 2020, 210–212).

Book / eBook

Dinçol, A. M., & Kantman, S. (1969). *Analitik arkeoloji: Denemeler*. Edebiyat Fakültesi Basımevi.

Peterson, J. (2002). *Sexual revolutions: Gender and labor at the dawn of agriculture.* AltaMira Press.

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Akkermans, P. M. M. G., & Schwartz, G. M. (Eds.). (2003). *The archaeology of Syria: From complex hunter-gatherers to early urban societies (c. 16,000–300 BC)*. Cambridge University Press.

Esin, U. (1995). Aşıklı Höyük ve radyo-aktif karbon ölçümleri. İçinde A. Erkanal, H. Erkanal, H. Hüryılmaz, & A. T. Ökse (Eds.), *İ. Metin Akyurt - Bahattin Devam anı kitabı. Eski Yakın Doğu kültürleri üzerine incelemeler* (ss. 135–146). Arkeoloji ve Sanat Yayınları.

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In-text citation: (Esin, 1995; Akkermans & Schwartz, 2003; Özkaya & San, 2007)

Translated book

Foucault, M. ([1954]2011). *Madness: The invention of an idea.* (A. Sheridan, Trans.). Harper Perennial Modern Thought.

In-text citation: (Foucault, 2011)

Dissertation & Thesis

Mosek, E. (2017). Team flow: The missing piece in performance [Doctoral dissertation, Victoria University]. Victoria University Research Repository.

In-text citation: (Mosek, 2017)