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Preliminary result of archaeological and petrographic classification of Neolithic pottery from Bahçelievler settlement in Northwestern Anatolia

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ABSTRACT

In prehistoric archaeology, pottery is a significant fragment in defining and making sense of the culture. The pottery forms and the differences in the variety of decorations are used together with other archaeological elements in the stratification of the settlement at the local scale. Bahçelievler settlement is located in the southeast of the Marmara Sea and in a mountainous area, unlike many other settlements with similar cultural characteristics. Bahçelievler Neolithic settlement was inhabited for the first time between 7192 and 7052 BCE and continued to be used until 6063–5971 BCE. Therefore, the settlement in question has a crucial role in the beginning and development of the Pottery Neolithic Period, especially in Northwestern Anatolia. Both the differences in form variation and the change in decoration preferences, as well as the changes in undefined stone, limestone, quartz, volcanic rock, basalt, etc. additives, provide meaningful results in the settlement stratigraphy. As a result of petrographic research, Bahçelievler Neolithic potteries are divided into four main groups and are very compatible with the archaeological classification. Clay and clay paste used in pottery are almost entirely consistent with local clays. It has been understood that the tempered material, which is strictly compatible with the geology of the immediate environment, is preferred for pottery. Although different forms and ware groups were selected chronologically to evaluate all the data together, it can be quickly asserted that the samples were of local production.

1. Introduction

One of the significant problems of archaeology is the classification of pottery (Ericson and Stickel, 1973:357; Almasi et al., 2017:29). The most common methods used in the classification of this material are the form variation typological distinctions (Kuhrt, 2009: 12; Whallon, 1972; Gilboa et al., 2004:681) and decoration application (David et al., 1988:365) techniques. Although identification, classification, and cultural comparisons according to the variety of pottery forms and decorations have a long history, they also pioneered the development of archaeology. However, in archaeological excavations, the number of examples in which all vessels, forms or decorations are always understood is either absent or very few samples. Especially when trying to extract information from small pieces or if a quantitative study is done, the points mentioned above consist of some limitations. Despite all these questions and problems, the variety of forms and the scale of decoration

allow us to understand a significant cultural change or transition as they could be sensitive to temporary fashion for the period. missing data.

It should be remembered that the classification of form and decoration data have their problems, especially for prehistoric periods. The first and perhaps most important of these problems is that every vessel has yet to be produced in a standard mould. They are usually unique in form with identical features. The second problem needs to include data. For instance, depending on the width-to-height ratio, base diameter, or the number of handles, it may be possible to assign the form of a complete pot to a class correctly. However, if there is only one part of the form that makes up the pots group in question, it presents more than one option in classification. The second problem is the possibility of minimizing the error rate. By recording objective facts about the vessel from which a piece of pottery came, an estimate can be made based on the pottery knowledge of the period. However, it is sometimes possible to test the accuracy of this assumption when only one piece is identified.

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Then, more are found from another vessel belonging to the same group. In addition, the wall thicknesses and the similarity of the ware group that can be determined in the construction techniques can also help to classify the vessel form most accurately. In short, the most common way of presenting the diversity of pottery includes a series of form types in which each type specimen represents a group of vessels considered to be more or less “same” in shape (Adams and Adams, 1991: 47-49; Ericson and Stickel, 1973:358-361).

Decoration grouping is another critical parameter studied extensively in pottery classification. As in the form classification, it is sometimes difficult to say something about the general design based on the small potsherds which the decoration groups have created. However, even in these cases, it is possible to describe the tools used with the decoration application and its technique.

In addition to the clays, the chief material of the pottery, other materials can be added to the dough and/or the surface of the pots. In recent decades, by using Petrographic analysis developed by geologists to identify minerals in rocks (Childs, 1989:24), archaeologists have been able to temper the clay composition, the classification of pottery, its form and decoration.

In this study, Bahçelievler pottery was classified based on the ware group, surface colour, pottery form, surface decoration variety and techniques, and the differences in temper in the clay. Thus, some selected speciality sherds were analyzed by petrographic analysis and grouped by mineralogical sheet apart from archaeological classification.

In petrographic examinations, the mineralogical contents (Eroğlu and Çalık, 2023: 129) of pottery fragments and their structural properties can be determined. Although XRD is the most effective method used for mineralogical analysis (Schreiner et al., 2004; Creanga, 2009) in pottery archaeometry, thin section analyses can also provide confirmatory or supporting mineralogical information depending on the content of the study and is a critical analysis method used to test the accuracy of archaeological macro-observations. Therefore, in this study, the contribution variation determined by macro-observations and archaeological terminology was tested petrographically. Thus, a clearer understanding of the pottery production process and production diversity enabled more accurate interpretations to be made. Due to the many interpretations that pottery is a material transported from other regions with the diffusionist paradigm, petrographic analysis was especially preferred in this study in terms of the potential effect of the clay and minerals used in northwestern Anatolian Neolithic pottery in solving the raw material source area problem.

Analysis techniques used in pottery classification produce more accurate and consistent results because complementary methods support them. Petrographic analysis was particularly preferred in this study, as examining the material with only a single method, such as macro-observations and archaeological classification, can often provide generalizing and limited information. This study includes detailed archaeological and mineralogical research, and we aim to reach more meaningful outputs by bringing together the preliminary results. As a result of all these, we believe that because of the widespread use of the petrographic and detailed pottery classification method, which is rarely used in Northwest Anatolian pottery, we will be able to express more unambiguous sentences about the Neolithization of Northwestern Anatolia and/or the pottery tradition.

2. Brief overview of the Neolithization and Fikirtepe culture from Northwestern Anatolia

Assuming that the Neolithic period in Northwestern Anatolia was the final phase of the alleged process in which the first agricultural activities spread from east to west, this region is often referred to as the “Late Neolithic” in the Anatolian chronology (Alpaslan-Roodenberg and Roodenberg, 2021). M. Özdoğan listed the spread of neolithic cultures regarding generations by evaluating the Levant, Mesopotamia and Iranian Zagros in Zone A, the Neolithic of Central Anatolia and the Lakes

Region in Zone B. Western Anatolia and the Marmara Sea surroundings, representing the last pre-European ring, in Zone C, it is argued that the centre of origin starts from the east and continues towards the west (Özdoğan, 2014). Additionally, Özdoğan claimed Anatolia was almost wholly unrelated to Thrace and developed under the influence of Mesopotamia-Central Anatolia. He claims the spread, which started from the Lakes Region, spread southwards to the Aegean Sea coasts and northwards through the Sakarya Basin to the northwest (Özdoğan, 2011).

Previously, the Northwestern Anatolian Neolithic was not considered as necessary a region as Levant, Mesopotamia, or Central Anatolia. For this reason, the pottery that existed in the area with local characteristics has often been categorized as an Anatolian and/or Balkan-influenced subculture (Özdoğan, 1997:19-23; Steadman, 1995:27; Özdoğan, 2011:26,28; Yakar, 2005: 31). Many Neolithic settlements on the Marmara Sea coast and east were evaluated within the scope of Fikirtepe Culture, which became evident after the “Early Neolithic” period (Özdoğan, 2011). This culture has spread over a wide area along the coasts of the Marmara Sea, but especially in Eastern and Southern Marmara. Moreover, Yenikapı excavations and Yarımburgaz Cave (Özdoğan and Koyunlu, 1986) proved that this culture also spread to the western side of the Bosphorus. However, due to the lack of excavations, its distribution in the eastern parts of the Marmara Sea and mountainous areas is not yet evident. However, it is also known that, with the Bahçelievler settlement, Fikirtepe Culture spread towards the inner parts of Anatolia, as can be understood from the Demircihüyük (Seeher, 1987), Keçiçayırı (Sarı and Akyol, 2019) and surveys conducted in Eskişehir (Efe et al., 1995; Efe et al., 2015).

However, in recent years, the pottery of Northwestern Anatolia seems to have gained the meaningful attention that it deserves thanks to ongoing archaeological excavations in the Barçın, Uğurlu, Yenikapı and Bahçelievler settlements. Over time, the quality and quantity of the pottery culture in these areas will increase. As a result, the pottery characteristics of their culture will be as crucial as Mesopotamian, Levant, Anatolian, and Balkan pottery.

A substantial increase in historical and archaeological studies transformed our knowledge of the Western Anatolian Neolithic Period. Ulucak Höyük (Erdoğu and Çevik, 2020), Gökçeada Uğurlu-Zeytinlik (Erdoğu, 2017) and Çukuriçi (Horejs, 2016) located in Western Anatolian coastal region together with the Bahçelievler settlement (Fidan, 2020; Fidan et al., 2022) and Barçın Höyük (Gerritsen et al., 2013) in Northwestern Anatolia are some of the most prominent studies. Although these studies on the early settlements provide significant details regarding the cultural characteristics of the Neolithic Period in pre-6500 BCE, they also suggest new argumentations on the beginning and development of Neolithization in Western Anatolia. Some scholars have also argued that the Western Anatolian Neolithic items date back to earlier than previously identified (Horejs et al., 2015; Çilingiroğlu, 2017; Guilbeau et al., 2019; Fidan et al., 2022).

The production of pottery dominated by dark colours, first unearthed in the Fikirtepe settlement, has been associated with the Fikirtepe culture, as have similar finds in many settlements, primarily based on specific characteristics of this community, such as incised decoration and burnished surface (Özdoğan, 2013:173; French, 1967: 56). This culture in question is divided into three main groups as Archaic, Classical and Advanced Fikirtepe, mainly based on pottery finds (Özdoğan, 1979). Almost all Fikirtepe’s pottery ware groups are mineral tempered. The absence of organic additives is generally emphasized in the pottery finds that constitute the main character of this culture (Erdoğu, 2014). Pottery samples with small amounts of plant tempered are found in a specific type of vessel belonging to the Fikirtepe E4 ware group, a large and shallow oval vessel (Özdoğan, 2023:53), in Pendik (Çilingiroğlu, 2012), and the Ilpınar X layer is seen (Roodenberg et al., 2003:36).

Fikirtepe, Yenikapı, Pendik, and Aktopraklık settlements located on the southern and northern shores of the Marmara Sea (Fig. 1) show similar characteristics in terms of architectural settlement pattern and



Fig. 1. Map of study area showing location of selected settlements in northwestern Anatolia and the Bahçelievler settlement (Sites 1: Yarımburgaz, 2: Yenikapı, 3: Fikirtepe, 4: Pendik, 5: Ilıpınar, 6: Mentеше, 7: Barçın, 8: Bahçelievler, 9: Demircihüyük, 10: Aktopraklık, 11: Uğurlu, 12: Ulucak, 13: Çukuriçi, Cities a: Istanbul, b: Çanakkale, c: Bursa, d: Eskişehir, e: Ankara, f: Izmir, g: Muğla) (Drawing by S. Sarıaltun).

pottery, Ilıpınar, Mentеше and Barçın Höyük, located further east, with their wooden perforated rectangular architecture and partial differences in pottery, indicate a differentiation (Özdoğan, 2023:20). However, the Bahçelievler settlement, which is located closer to these settlements and in the mountainous woodland area to the east, exhibits similar characteristics to the settlements on the coast of the Marmara Sea, especially in terms of architectural building tradition and building plan features, despite the apparent differences in its pottery. Considering that the Bahçelievler settlement, which has an earlier date than the Barçın Höyük settlement, exhibits similar characteristics with the Marmara Coast settlements in terms of both its architecture and pottery, but also the diversity and similarities of both the pottery ware groups and the decorations on the pottery in the Barçın Höyük cultural fillings phase, it has become clear that Fikirtepe culture needs to be re-evaluated through studies using multi-layered perspective. In this study, through the interdisciplinary evaluation of the pottery material in terms of archaeology and petrography, it is evident that this problem will snowball effect on the beginning of the solution. Therefore, the data presented in this study raises thought-provoking and questionable questions for researchers studying settlements with Fikirtepe Culture deposits.

3. Case study: Archaeological, spatial and environmental setting from Bahçelievler settlement and its vicinity

3.1. Archaeological features of Bahçelievler settlement

Bahçelievler settlement is located in the southeast of the Marmara Sea and, unlike many other similar cultural settlements, it is in a mountainous area (Fig. 1). A total of eight architectural levels were identified in the Bahçelievler settlement. The uppermost Level 1 is dated to the Archaic Period, while the other seven levels (2–8) reflect the

cultural characteristics of the Neolithic Period. Bahçelievler Neolithic settlement was inhabited for the first time between 7192 and 7052 BCE, and its use continued until 6063–5971 BCE. As such, the settlement was crucial in the beginning and development of the Pottery Neolithic Period in Western Anatolia. Level 8, the oldest settlement level, is dated 7192/7052–6850 BCE (Fidan et al., 2022). The few sherds found in this phase, which is represented by an oval house with a semi-pit bottom carved into the main soil, represent the oldest known pottery of Western Anatolia. It can be argued that the round/oval architectural tradition, built with the wattle-and-daub technique, continues with stylistic changes in the 7th and 3rd levels of the settlement, dated between 6850 and 6100 BCE. Level 2 is the last prehistoric phase. This level dates between 6100 and 6000 BCE, and it has given its place to a rectangular architecture.

3.2. Geological background of the physical environment from Bahçelievler settlement

Bilecik and its surroundings are in the western part of the Sakarya zone, one of the Turkish tectonic units, in the “Inner Pontide Suture zone” (Fig. 2) (Okay and Göncüoğlu, 2004). The Karakaya Complex, widespread in the Sakarya Zone, consists of sedimentary and volcanic rocks partially metamorphosed in the Late Triassic. The basement rocks in Bilecik and its surroundings begin with the Upper Paleozoic-Triassic aged Nilüfer Formation (schist, phillite, marble, metabasites) belonging to the Karakaya complex. Metabasites are of basic tuff, agglomerate, and pillow lava origin. There is also a tiny amount of chert in the unit. Permo-Triassic-aged Orhanlar Greywacke (carbonate and clastic rocks) overlies this unit with tectonic contact (Okay and Whitney, 2010). The uppermost unit of the Karakaya complex is the Triassic-aged Abadiye formation (basalt and syphilitic basalt), which unconformably cuts through the lower units. A Jurassic-Cretaceous aged sedimentary

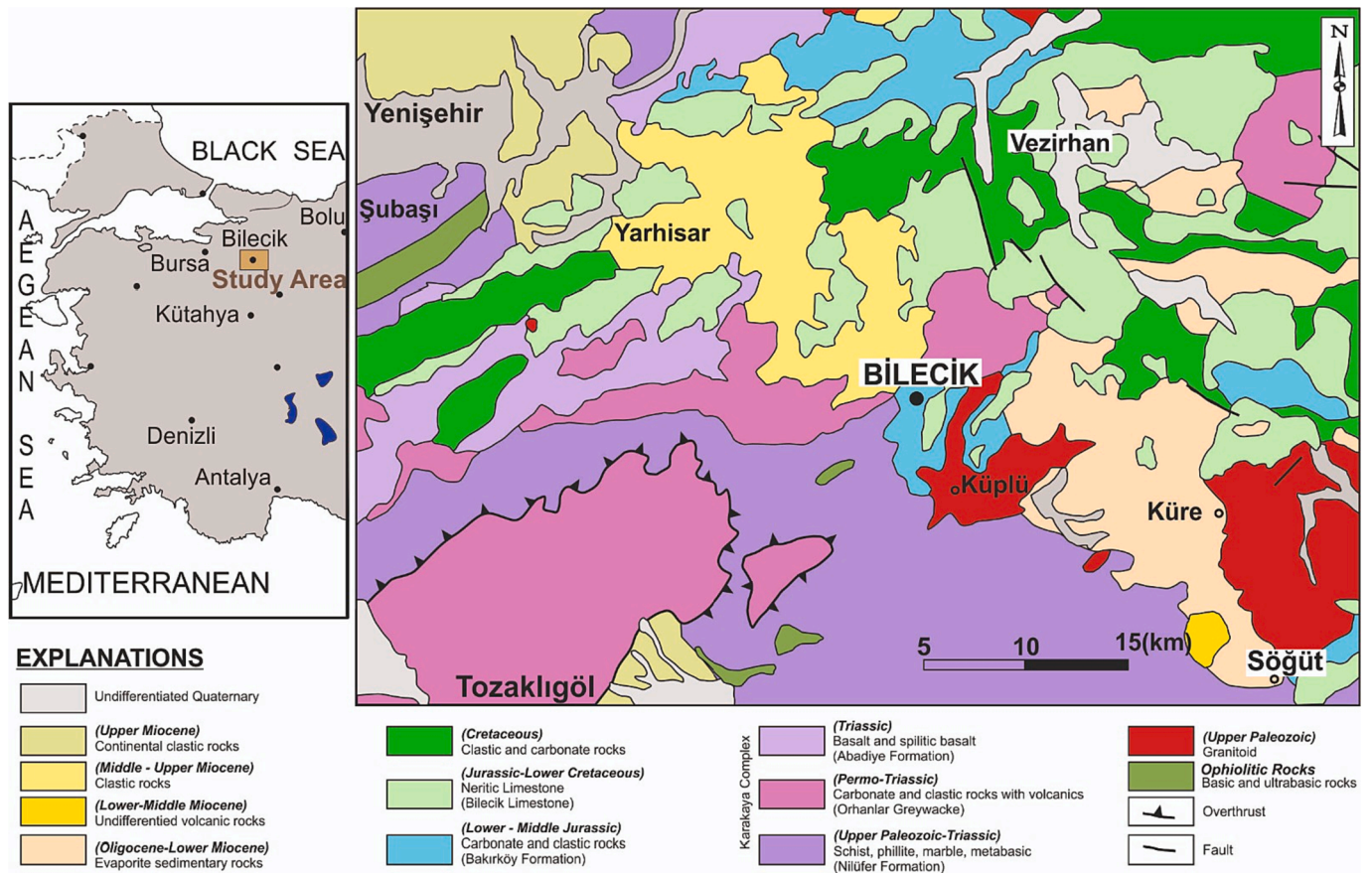


Fig. 2. Generalized geological map of the Bilecik and surrounding area (Modified from MTA, 2002; Drawing by B. Semiz).

succession unconformably overlies the Karakaya complex. Lower-Middle Jurassic aged Bakırköy formation (carbonate and clastic rocks) at the bottom of this succession consists mainly of sandstone, conglomerate, and siltstone. The Jurassic-Lower Cretaceous Bilecik limestones overlie the Bayırköy Formation (Okay and Whitney, 2010). Oligocene-Miocene aged units are observed unconformably on Bilecik limestones. Upper Paleozoic aged Söğüt magmatites (Granitoid) observed in the region are igneous rocks and ophiolitic rocks mainly composed of peridotite, gabbro, pyroxenite and diabase spread in small areas (Kadioğlu et al., 1994). Quaternary-aged alluviums unconformably cover all units.

4. Materials and methods

Two methods were preferred to classify Bahçelievler pottery. First, the pottery found in the settlement was classified in terms of archaeology, and some preliminary determinations were made in chronology. Then, the finding has petrographically been analysed to understand the quality and quantity of clay used and its mineralogical composition. The most important reason for this analysis is to test and/or verify archaeological determinations. The quality and composition of the pottery were discussed and evaluated by subjecting them to mutual evaluation using these methods.

This article covers the chronological differences, artistic changes and production techniques of the pottery obtained from the Bahçelievler Neolithic settlement and the archaeological and petrographic classification of the mineralogical clay composition. In this article, special attention was given to chronological determinations based on the decorated sherds found in the architectural levels. Accordingly, commodity groups are primarily based on surface colour; secondly, according to the clay taxonomy and the variety of additives added to the

dough as a conscious choice; and the additive size-ratio. Thirdly, they were classified according to their vessel shapes and their decoration and surface treatments. In addition, and mainly, the pottery sherds examined in this study focus on the chronological determination of diagnostic (identified) samples taken from reliable deposits or related to the architectural layers of the Bahçelievler Neolithic settlement. Parts in complex and unreliable units, such as mixed fills, garbage areas, and non-diagnostic (unidentified) body parts, are expressly excluded from statistics.



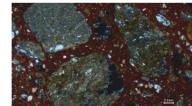

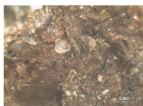
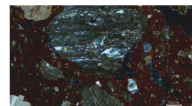


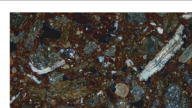

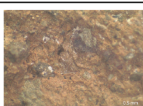
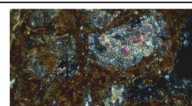

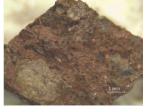
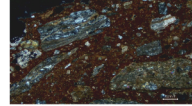


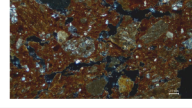


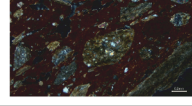

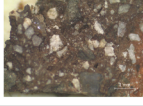
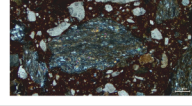

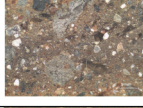
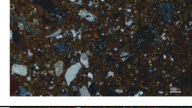


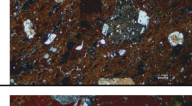

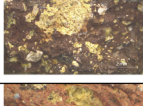



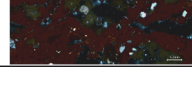
A total of 5130 sherds recovered from the Bahçelievler excavations were subjected to rough examination in the Archaeology Laboratory of Çanakkale Onsekiz Mart University. A total of 1116 potsherds, which can be identified by considering their profile features, were examined one by one and in detail. Detailed data were obtained by asking 30 questions such as ware groups, wall thicknesses, temper quality and quantity, surface properties such as slip-burning, production and firing techniques, shape and form groups, and decoration quality of the pottery in question.

Especially the book of Özdoğan (2023) was widely used in the ware classification of the pottery group. However, the terms used in defining dough properties, tempered variation, wall thicknesses and surface treatments based on Ökse (1999) and granule size-ratio definitions were based on Boggs (2012).

A Total of 24 samples was selected to determine the petrographical and mineralogical properties of the samples, which differ according to their macroscopic properties (colour, shape, etc.) (Table 1). The interior and exterior colours of the samples were measured in the Department of Geological Engineering (Pamukkale University) by PCE-CSM1 Colorimeter. "Munsell Soil-Colour Charts 2010" colours are defined by making colour conversions of all measured colours. The macroscopic descriptions of the samples were examined with the Leica EZ4 W

Table 1

Identification of the outer and section colors and forms of the selected samples (The CIE LAB is a widely used color system: L* (lightness) ranges from black (0) to white (100), the a* value ranges from red (+128) to green (-128), and the b* value ranges from yellow (+128) to blue (-128)).

Group	Sample Number	Forms	Form No	Ware	Shape	Stereo-microscope	Thin Section (Xpl)	L*	a*	b*	Muncell Color
Group 1	152		6d	Reddish brown coloured Ware	Jar			42.91	7.22	14.67	7.5YR 4/4 (Brown)
								36.43	8.45	13.64	5YR 4/4 (Reddish brown)
	282		6a	Dark Surfaced Deep Brown Ware	Jar			47.58	8.58	16.99	7.5YR 5/4 (Brown)
								39.27	4.11	11.08	10YR 4/2 (Dark grayish brown)
	446		6a	Buff coloured Ware	Jar			50.92	7.88	17.25	7.5YR 5/4 (Brown)
								39.61	7.20	12.94	7.5YR 4/4 (Brown)
	635		6a	Dark Surfaced Deep Brown Ware	Jar			52.39	9.74	20.35	7.5YR 5/4 (Brown)
								39.85	7.44	14.63	7.5YR 4/4 (Brown)
	1024		4b	Buff coloured Ware	Bowl			48.51	11.77	19.21	7.5YR 5/4 (Brown)
								39.38	5.67	11.67	7.5YR 4/2 (Brown)
1048		5a	Matt Brown Ware	Jar			48.78	9.22	17.06	7.5YR 5/4 (Brown)	
							44.46	12.55	19.76	5YR 4/4 (Reddish brown)	
1350		6c2	Dark Surfaced Mottled Brown Ware	Jar			40.93	4.46	11.81	10YR 4/2 (Dark grayish brown)	
							36.55	3.38	9.42	10YR 4/2 (Dark grayish brown)	
Sub-group 1	634		5a	Red coloured Ware	Jar			54.04	12.32	24.93	5YR 5/6 (Yellowish Red)
								43.77	3.70	9.99	10YR 4/2 (Dark grayish brown)
Sub-group 1	1094		6c2	Red coloured Ware	Jar			53.29	17.16	22.23	5YR 5/6 (Yellowish Red)
								41.10	8.32	13.33	5YR 4/4 (Reddish brown)
Group 2	302		6c1	Reddish brown coloured Ware	Jar			43.13	10.59	17.08	7.5YR 4/4 (Brown)
								36.10	6.58	11.76	7.5YR 4/2 (Brown)
	568		6a	Matt Brown Ware	Jar			43.45	5.70	14.83	10YR 4/4 (Dark yellowish brown)
								37.84	6.87	15.85	10YR 4/4 (Dark yellowish brown)
	637		3a	Red coloured Ware	Bowl			52.94	15.87	22.89	5YR 5/6 (Yellowish Red)
46.88								15.20	23.10	5YR 5/6 (Yellowish Red)	

(continued on next page)

Table 1 (continued)

	1019		6e	Matt Brown Ware	Jar			50.21	9.54	18.33	7.5YR 5/4 (Brown)
								51.14	7.50	19.43	10YR 5/4 (Yellowish brown)
Group 3	818		6b	Dark Surfaced Mottled Brown Ware	Jar			44.90	6.65	17.09	10YR 4/4 (Dark yellowish brown)
								43.95	12.41	16.09	5YR 4/4 (Reddish brown)
	839		6a	Red coloured Ware	Jar			53.74	19.29	26.05	5YR 5/6 (Yellowish Red)
								54.17	15.24	22.75	5YR 5/6 (Yellowish Red)
Sub-group 3	964		5d	Buff coloured Ware	Jar			42.31	15.75	20.22	5YR 4/6 (Yellowish Red)
								52.25	8.79	15.28	7.5YR 5/4 (Brown)
	968		3b	Dark Surfaced Mottled Brown Ware	Bowl			49.81	13.63	24.09	7.5YR 5/6 (Strong Brown)
								49.87	14.66	15.11	2.5YR 5/4 (Reddish brown)
Group 4	346		6b	Matt Brown Ware	Jar			30.43	1.94	5.79	10YR 3/2 (Very dark grayish brown)
								37.25	6.14	12.52	7.5YR 4/2 (Brown)
	815		3b	Matt Brown Ware	Bowl			39.03	10.21	15.49	5YR 4/4 (Reddish brown)
								39.96	10.40	16.16	5YR 4/4 (Reddish brown)
Sub-group 4	1309		3b	Dark Surfaced Deep Brown Ware	Bowl			38.62	2.32	7.84	10YR 4/2 (Dark grayish brown)
								38.90	8.25	14.64	7.5YR 4/4 (Brown)
	1057		3b	Dark Surfaced Mottled Brown Ware	Bowl			43.63	8.43	14.59	7.5YR 4/4 (Brown)
								37.45	10.38	16.05	5YR 4/4 (Reddish brown)
Other	540		4b	Buff coloured Ware	Bowl			55.60	11.50	24.05	7.5YR 5/6 (Strong brown)
								47.31	10.80	20.31	7.5YR 5/4 (Brown)
Other	544		4a	Buff coloured Ware	Bowl			55.32	18.06	31.05	7.5YR 5/8 (Strong brown)
								49.92	11.90	22.86	7.5YR 5/6 (Strong brown)
Other	848		5b	Red coloured Ware	Jar			45.80	15.32	21.13	5YR 4/6 (Yellowish red)
								48.58	14.19	20.72	5YR 5/6 (Yellowish red)

stereomicroscope. Thin sections of 24 samples for petrographic studies were made in the thin section laboratory at the Department of Geological Engineering Pamukkale University (PAU). Thin sections of the samples were taken to show all layers from the outside to the inside. The prepared thin sections were examined with the Leica DM750P polarising microscope, and their mineralogical and petrographic properties were tried to be determined (Semiz et al., 2018a, 2018b; Semiz, 2021).

The missing part of this study is that the sherds found in Bahçelievler Neolithic Settlement were not analysed by XRF and XRD methods. These two analysis methods will be used later. Therefore, the existing clays in the region and the pottery clays found in the mentioned settlement will be mutually evaluated, and more accurate results will be achieved.

5. Results and discussion

Bahçelievler Neolithic Period pottery is divided into eight ware groups (Fig. 3). Buff, cream, and matt brown wares were preferred or produced in layers 8 and 7 than in other layers. In the upper levels, such as 3 and 2, dark-surfaced black, dark-surfaced brown, and dark-surfaced mottled brown wares were preferred more intensely. Red and reddish-brown wares were prominent in Level 6 and were used more intensely in Level 4. Volcanic rock, limestone-marble, quartzite, basalt or syphilitic basalt, and unidentified stone inclusions determined in Bahçelievler pottery can be divided into three subgroups according to production technique and temper properties. The first group is gravel, stone, coarse sand, etc., casual goods. The second group consists of basalt or volcanic rock tempered wares, and finally, the third group consists of quartz or limestone-marble-added wares. However, the intense use of the sandy clay found in the Bahçelievler settlement is a vital disadvantage affecting the pottery making. As a result of the sandy texture of the pottery dough, the clay dough loses its plasticity, albeit partially, and therefore, it becomes complicated to make thin-walled vessels. Likewise, the number of 0.5 mm thick-walled vessels in Bahçelievler pottery is relatively low. Fine sand or plain clay features were detected in almost all the walled vessels under 0.5 mm thickness. The number of these thin-walled vessels increases after Level 4, and the wall thicknesses were found to be 0.7 mm thicker in earlier phases.

The ware groups in Bahçelievler levels 8 and 7 potteries, dated to the beginning of the 7th Millennium BC, which form the oldest pottery group of Western Anatolia with our current knowledge, are quite like each other. The vessel forms are far from diverse, while the box-shaped vessels are absent, and the number of open-mouthed pots is very few samples. Diagnostic pottery sherds identified reflect closed pot forms, generally defined as pottery groups. In the 6th level, dated to the middle of the 7th Millennium BC, significant differences were observed in the Bahçelievler Neolithic pottery-making tradition.

The conventional characteristic of Fikirtepe pottery is the dark-surfaced wares, and the sherds with incised decoration are revealed together with this phase. In addition, there is a significant variation in the Bahçelievler Neolithic vessel forms with this level. Conical body bowls, "S profile" bowls and shallow-necked spherical body pots are seen together with the narrow-rimmed pots. A few box-shaped are also seen in this area. One of the apparent differences in Level 6 is the colour change on the vessel surfaces. Dark tones begin to gain weight on the vessel surfaces of this level, and buff-cream-light brown-brown tones decrease compared to previous phases. In addition, orange and red tones become evident in the colour of the pottery clay. For example, mica is evident in the clay of Level 6, but especially in reddish-brown/red/orange-coloured clays. Petrographic analyses revealed that these micas were not micas, but all of them were pyroxene. Therefore, the contribution of mica in the definitions of Fikirtepe pottery should now be regarded with suspicion. Mica suggested in many studies that it may be pyroxene. In Level 4 of the settlement, the red/reddish-brown wares significantly increased; fragments with incised decoration became evident, and the variety of motifs increased. Another distinguishing feature of Level 4 is the significant increase in box-shaped vessels and

the diversification of "S-profile" sherds. The pottery belonging to levels 3–2 of Bahçelievler, dated to the end of the 7th millennium BC, generally consists of dark-surfaced wares (Table 2).

The box-shaped, which is the phenomenal vessel form of the Northwestern Anatolian Neolithic (Özdoğan, 2013:174; Schwarzberg, 2009:167), significantly increased in number at this level. Another difference in these levels is the increased diversity in vessel forms. In particular, the number of "S-profile" vessels has grown and has gained a quality that can be divided into subgroups. In addition, it was determined that the number of long-necked spherical-bodied pots increased with this phase. Both the profile variety and the decoration variety of the pottery recovered in Level 2 differ significantly compared to Level 3.

The pottery found in the Bahçelievler Neolithic settlement has been classified and examined into 13 groups according to various motifs engraved on the surface (Table 3). We can name these decorations as follows: 1-Triangles, 2-Butterfly motifs, 3- Cross-hatching, 4-Bands, 5-Checkerboard motifs, 6- Lozenges, 7-Zigzags, 8- Stair motif, 9-Simple Lines, 10-Plus (+) motif, 11-Struts, 12-Sun motif, 13-Composite decorations. Most of the vessel forms with decorations are box-shaped vessels. In addition to this, various decorations were substantially engraved on open-formed pots, such as bowls. Decorations were encountered on the necked spherical body jars, albeit rare. The number of pieces whose form cannot be determined is minimal. No dominance was detected in a particular ware group in the decorated sherds. However, although the number of decorations is higher in the dark-surfaced black, deep brown and red wares in Levels 4 and 2, the number of decorations is higher in the lighter-coloured wares such as brown and buff in Levels 6 and 5 compared to the upper phases. No decoration was detected on the surface of the cream wares (Fig. 3) in any of the levels. The most common motif in Bahçelievler decorated pottery is triangles, while the second most common motifs are Cross-hatching and bands. The third one is the checkerboard motif. Another group in Bahçelievler decoration classification is zigzag motifs, which are fewer in number. Apart from all these, a few decorated sherds with plus, struts, suns and complex motifs were also found. The decorations classified as a cross-like plus (+) motif were found only in Levels 4 and 3 from Bahçelievler settlement. The struts motif was used only in Level 6. The sun motif was detected in one piece and used in Plate 4 of this settlement.

The selected 24 samples, which were examined mineralogically and petrographically, are divided into four main groups (Fig. 4). Generally, all samples are poorly graded and contain abundant rock fragments and few minerals. The first group includes abundant metabasite, mica schist and lesser amounts of gabbro, chert, limestone, and marble (Fig. 5a). Within the sample group, a significant increase in limestone and marble contents is observed in some samples. Rock particles are generally regarded as rounded-edged; marble fragments are usually marked as angular grains (Fig. 5b). It is seen that they also contain pottery fragments in some samples. The second group of samples is generally multi-void. It consists of volcanic rock fragments (dacitic) and, to a lesser extent, limestone, quartzite, and its fragments (Fig. 5c). The presence of quartz and pyroxene minerals in the samples draws attention. The third group samples are generally characterized by abundant limestone and marble contents. In addition, it was determined that they contain volcanic rock fragments, lime lumps and chert (Fig. 5d). In some samples, a significant increase in marble rates is observed. It is seen that the pieces of marble are angular (Fig. 5e). The fourth group of samples is distinguished by their syphilitic basalt contents (Fig. 5f). In addition, marble and silicic volcanic rock fragments were detected in the samples. In some of these samples, a significant increase is observed in gabbro, quartz and pyroxene minerals. It was interpreted that the firing temperatures of the samples were < 800°C because the marble pieces in all groups were in a particular proportion, and their composition was intact.

The other three samples were found to be different from the sample groups. The abundant pyroxene mineral in sample 540 is noteworthy (Table 1). In addition, chert, quartz, and lime lumps are also commonly

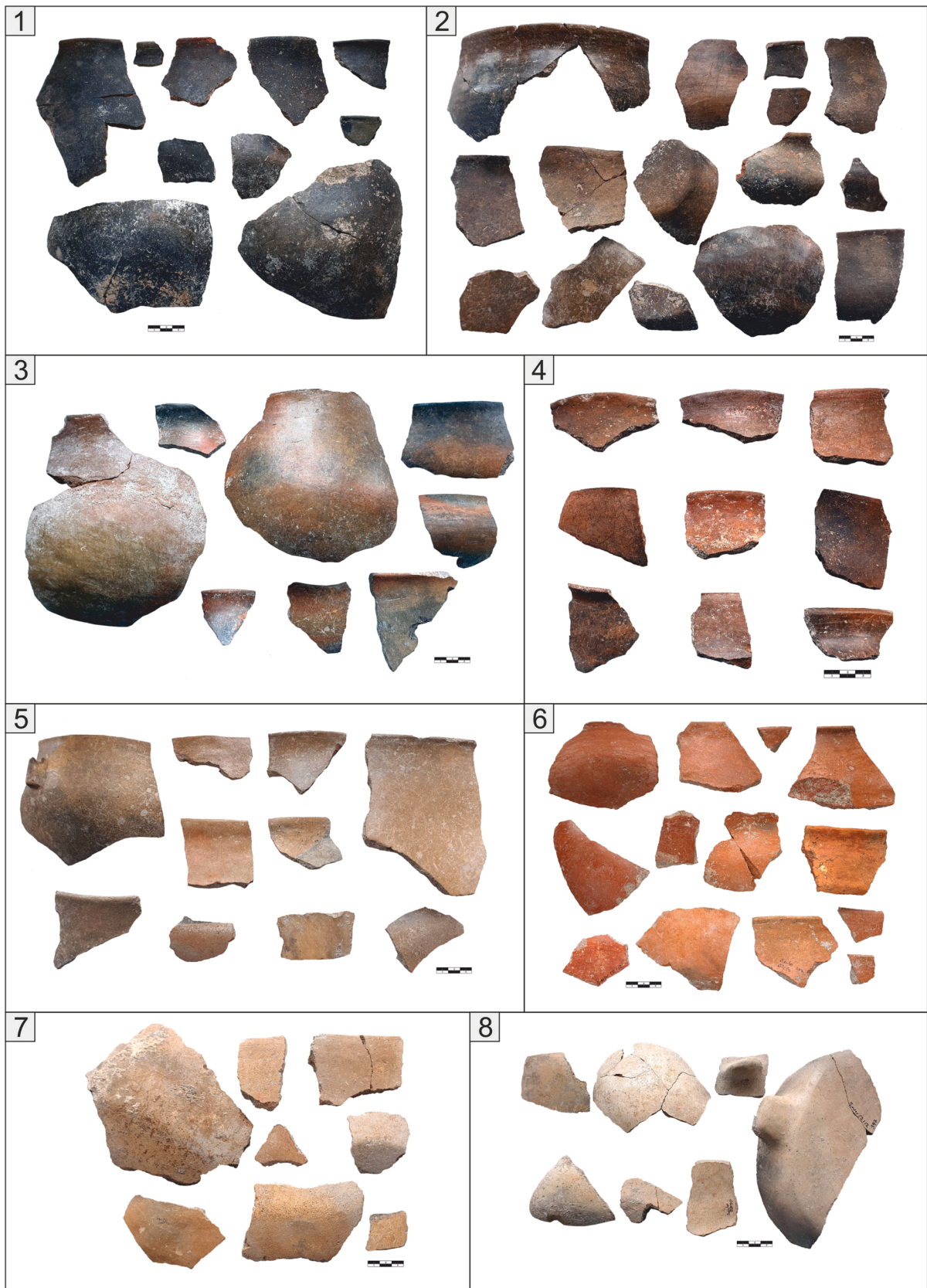


Fig. 3. Chart of ware groups by bahçelievler neolithic levels (1: Dark Surfaced Black Ware, 2: Dark Surfaced Deep Brown Ware, 3: Dark Surfaced Mottled Brown Ware, 4: Redbrown coloured Ware, 5: Matt Brown Ware, 6: Red coloured Ware, 7: Buff coloured Ware, 8: Cream Coloured Ware).

Table 2

Distribution chart of ware groups by Bahçelievler Neolithic Levels.

LEVELS	Dark Surfaced Black Ware	Dark Surfaced Deep Brown Ware	Dark Surfaced Mottled Brown Ware	Reddish brown coloured Ware	Red coloured Ware	Matt Brown Ware	Buff coloured Ware	Cream Coloured Ware
2	42	63	17	26	11	22	17	
3	37	58	22	28	21	59	21	
4	14	34	25	25	33	20	21	1
5	11	17	10	8	24	12	26	1
6	31	49	24	52	28	30	66	4
7	1	9	5	12	5	14	20	5
8	0	3	0	7	1	7	13	4

Table 3

Distribution chart of incised decoration by Bahçelievler Settlement Neolithic Levels.

Decoration Type	LEVELS								Undefined
	2	3	4	5	6	7	8		
Triangles	2	5	4	4	14				4
Butterfly		2	2		3				
Cross-hatching	12	3	1		6				2
Bands	7	3	4	7	5				
Checkerboard	4	1	2	2	2				2
Lozenges	1		2	1	1				1
Zigzags		3		1	6				
Stair	2	2		1	3				2
Simple Line	2		1		3				2
Plus		2	1						
Struts					4				
Sun			1						
Composite	1								
Undefined	1	3	2	1	2				6

observed. Sample 848 contains a significant amount of igneous rock particles. In addition, it was determined that they had chert, pyroxene, and a small amount of marble.

When the geological features of Bilecik and its surroundings are evaluated in general, very different lithological units belonging to the Sakarya zone are observed. In the south and west of Bilecik, metamorphic rocks and syphilitic basalts of the Karakaya complex are dominant, granitoid-type rocks belonging to Söğüt magmatic rocks in the east, and limestones are prevalent in the northern parts. According to the petrographic characteristics of the examined pottery samples, it is seen that the abundant metabasite, phyllite, marble and schist-type rocks contained in the group 1 samples, as well as the gabbro-type rocks it has, are related to the Niliüfer Formation. The abundance of volcanic rock fragments in Group 2 samples is thought to be related to the volcanics in the southeast of Bilecik. Group 3 samples contain abundant volcanic rock fragments and chert. It is thought that the marble-type rocks were deliberately added to the pottery samples as temper. Spilitic basalts in Group 4 samples are associated with the Abadiye formation. Pyroxene minerals, which are detected in small amounts in all samples, are thought to originate from metabasic rocks.

A petrographic examination of the composition of the rock particles in the samples provides helpful information about the origin of the clay paste (Semiz et al., 2018b). Rock particles ranging in size from approximately 0.5 to 2.5 mm were identified in the samples examined. By identifying these coarse rock particles, information about the geology of the region was provided. According to these data, when the geological

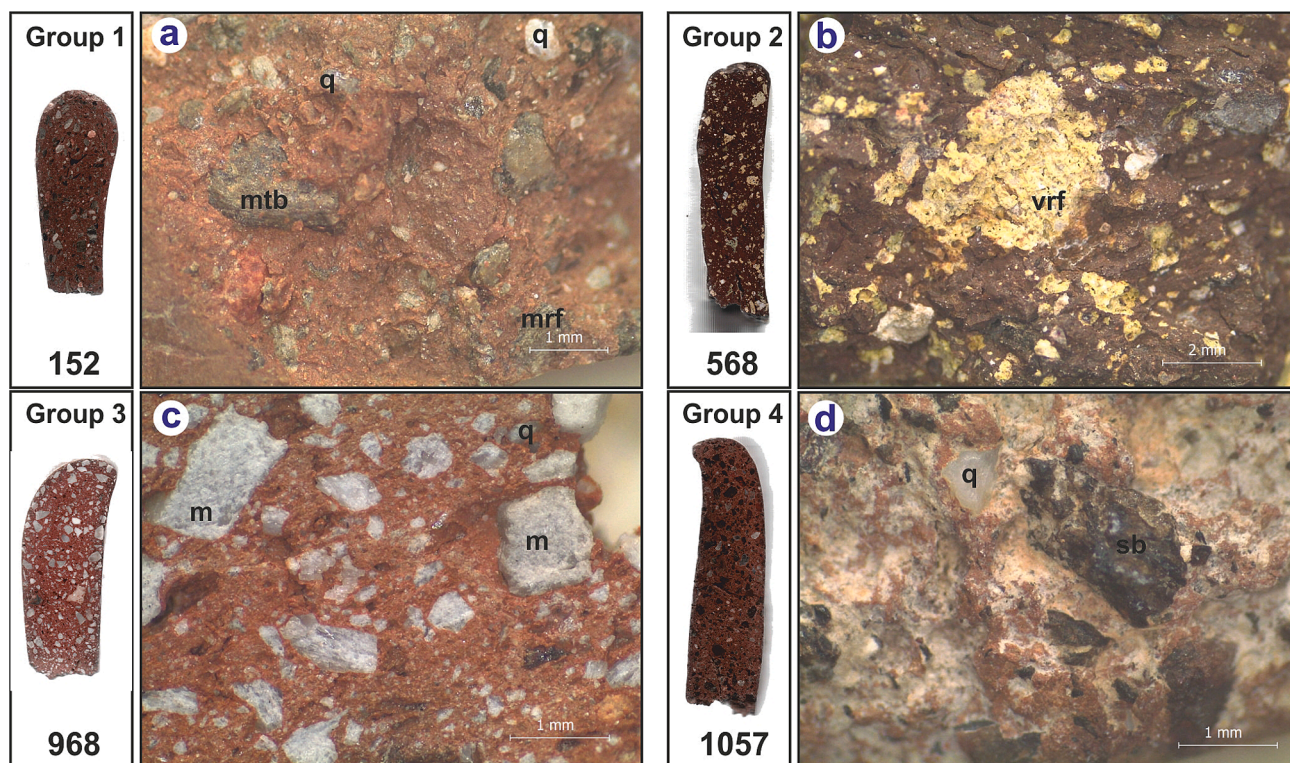


Fig. 4. Stereomicroscope views of the examined ceramic samples (mrf: metamorphic rock fragments; q: Quartz; vrf: volcanic rock fragments; m: marble; sb: syphilitic basalt).

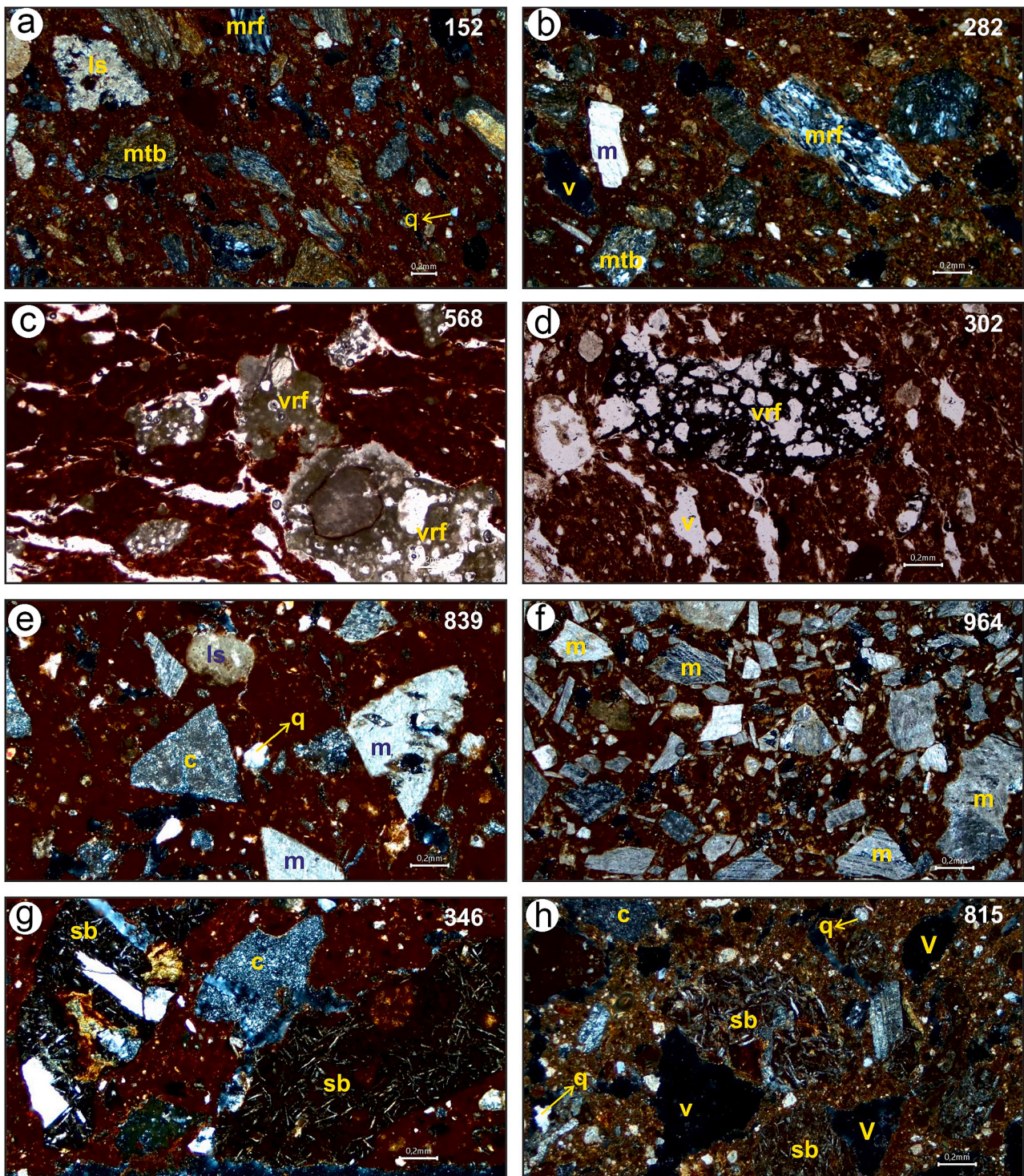


Fig. 5. Optic microscope views of the examined ceramic samples. a and b: Group 1 samples; c and d. Group 2 samples; e and f: Group 3 samples; g and h: Group 4 samples (ls:limestone; mrf: metamorphic rock fragments; q:Quartz; vrf: volcanic rock fragments; c:chert; m:marble; sb: spilitic basalt; mtb:metabasite v: void).

features of Bilecik and its surroundings are examined, it is seen that the lithology in the south of Bilecik and the rock particles contained in the pottery samples are precisely compatible. It is thought that they were produced with schist-type rocks and clays taken from geological units with syphilitic basalts located south of Bilecik. As a result of the comparison analyses to be made in the future, this preliminary argument will become apparent because it is seen that the rock particles in the pottery mainly originate from the rock particles in the clay. It is thought that the

marble-type rocks were deliberately added to the pottery samples as temper.

6. Conclusion

The Northwestern Anatolian Pottery Neolithic period is a complicated region, especially regarding classification comparisons, since the Fikirtepe culture and other pottery components often must be published

comprehensively. It has almost become a tradition to describe Fikirtepe culture as black-reddish-brown burnished pottery, usually decorated with simple forms and incised geometric motifs. The most important and unusual form group that distinguishes this culture from other cultural areas is the short-footed rectangular (box-shaped) vessels. However, it is understood that this is not the case in Bahçelievler settlement, as diverse decoration techniques have been implemented here, chronological differences are evident in the ware groups and, therefore, do not show a homogeneous/uniform cultural characteristic.

Both archaeological classification parameters and petrographic studies show that different methods and tempers are used in clay making. No significant relationship was found between this temper variation and the form group or ware group. Four other groups were defined according to petrographic studies. It has been determined that the first group consists of metamorphic rocks and metabasites, the second group consists of volcanic rock particles, the third group consists of marble and limestones, and the fourth group consists of syphilitic basalt-type rocks. It is thought that the firing temperature of 800 °C for the four ceramic groups was not exceeded. Although the only distinguishing feature is that volcanic basalt and undefined stones were used more intensively in the early stages, it is seen that limestone-marble-quartzite tempers increase significantly after the properties of Level 4. However, this distinction does not differ according to the form variation. It cannot be talked about that the choice of dough according to the functionality of the pot. Similar clay composition is used in all forms that are desired to be made, primarily for local characteristics.

Although different forms and ware groups were preferred chronologically because of evaluating all the data together, it is thought that the samples were of local production. The mineral and rock compositions detected within these ceramic groups indicate that they are compatible with the geological structure of the region and that the ceramics are probably local products.

Determining raw material sources is important in understanding the relationship network between the physical environment and the social environment. It may indicate the nature of the connections of the communities in the region with the paleoenvironment. The minerals already found in the region suggest that the Bahçelievler Neolithic community actively used raw material resources several tens of kilometres away to produce pottery. Its archaeological significance may enable some accepted propositions regarding pottery production in northwestern Anatolia and the process of interregional or local acculturation to be re-questioned and weighed. In this sense, it is evident that examining the pottery of the Bahçelievler Neolithic settlement, both archaeologically and mineralogically, will have an impact that can spark these discussions.

CRedit authorship contribution statement

Savaş Saraltun: . **Barış Semiz:** Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Sümeyya Ağaç:** Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. **Erkan Fidan:** Data curation, Investigation, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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