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ORIGINAL PAPER

# An integrated typological, technological and provenance investigation of Late Hellenistic colour-coated pottery from Nea Paphos, Cyprus

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## Abstract

The current paper contributes new evidence to the ongoing discussion of the location and organisation of production of Hellenistic colour-coated ware (CCW), through interdisciplinary investigation of morphological style, technology and provenance of relevant pottery from a Late Hellenistic deposit found in a well in the Agora of Nea Paphos on Cyprus. Through naked eye examination, four major macroscopic groups were identified based on vessel typology and fabrics. Subsequently, 53 representative samples were selected and analysed through a combination of refiring tests, chemical analysis, thin section petrography and scanning electron microscopy. The results indicated that the sheer majority of this pottery, despite some compositional and technological variability, reflects the use of similar raw materials compatible with the geology of Paphos. Therefore, during the Late Hellenistic period, most of the CCW consumed in Paphos were locally produced. The observed variation in the assemblage can be associated with several factors, such as natural diversity of raw materials, a number of co-existing pottery workshops, technological choices made by the potters and to a lesser extent post-depositional processes. This integrated research has a profound impact on studies of production and consumption of the Late Hellenistic pottery on Cyprus.

**Keywords** Cyprus · Nea Paphos · Colour-coated ware · Late Hellenistic period · Chemical analysis · Petrographic analysis

## Background and research questions

The colour-coated ware (CCW) is a class of fine pottery commonly used around sites in the Eastern Mediterranean from the beginning of the Hellenistic period until the Early Roman times (late fourth c. BCE–first c. CE; Table 1). It was originally defined and named by John W. Hayes in his publication of Hellenistic and Roman ceramics from the House of Dionysos in Nea Paphos (1991). Generally, CCW is characterised by the presence of a matt or semi-lustrous slip, whose colour can vary from red to black even within the same vessel. It is associated with tableware and includes a variety of forms, such as various types of bowls, plates and jugs, as well as unguentaria and lamps. It is widely accepted that the same or very similar shapes of CCW were produced at several places in the Eastern Mediterranean (e.g. Fenn and Römer-Strehl 2013: 377; Drougou 2014: 146). Based on archaeological evidence (Hayes 1991; Papuci-Władyka 1995) and chemical analyses (Picon and Blondé 2002), it has been suggested that Nea Paphos was one of the production places of CCW. The objective of this paper is to investigate further this suggestion addressing questions of provenance, technology and production organisation of the Late Hellenistic CCW pottery from Paphos,

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**Table 1** Relative and absolute chronology of Nea Paphos with indication of the pottery found in the well deposit from the Agora and the CCW production

| Period | Chronology | Important events | Pottery |
|---|---|---|---|
| Early Hellenistic | Late fourth–late third c. BCE | Late fourth–early third c. BCE: foundation of Nea Paphos | Late fourth c. BCE: the beginning of the CCW production |
| Middle Hellenistic | Late third–late second c. BCE | Late third–early second c. BCE: Nea Paphos becomes the capital of the island | |
| Late Hellenistic | Late second–late first c. BCE | 58 BCE: the Romans annexed Cyprus | Late second–third quarter of the first c. BCE: pottery from the well deposit at the Agora in Paphos |
| Roman | Late first c. BCE–293 c. CE | 17 or 15 BCE: earthquakes destroyed Nea Paphos | First c. CE: the end of the CCW production |

through the combined typological, compositional and technological studies of a ceramic assemblage from a closed deposit.[1] The latter, related to a sealed context from a well at the Agora in Nea Paphos, includes pottery dated from the late second to the beginning of the third quarter of the first c. BCE. It is particularly valuable as it provides securely and closely dated evidence on CCW production and consumption for a key period in the history of the site.

## The site and the pottery

Nea Paphos, located in southwestern Cyprus, at the crossroads of the main sea routes between East and West, was an important commercial and administrative hub for many centuries. It is believed that the city was founded either by Nicocles, the last king of Palaipaphos, in the late fourth c. BCE (Nicolaou 1966; Młynarczyk 1990: 66–105; Młynarczyk 1996: 193) or by Ptolemy I in the early third c. BCE (Bekker-Nielsen 2000; Balandier 2011: 376). The new city was divided into the residential (Maloutena, Ktisto), administrative (Fanari Hill) and commercial (Agora, harbour) districts (Fig. 1a). At the end of the third or in the early second c. BCE, it became the headquarters of the Governor of the island (Maier and Karageorghis 1984: 230; Młynarczyk 1990: 121–122). Not only was the city an administrative centre of the island but also a location of strategic importance in which the Ptolemaic fleet was stationed to be supplied as its geographic location allowed easy access to natural resources. The dense forests and the mineral ores located in the nearby mountains were particularly attractive to the Lagids and influenced the socio-economic and cultural development of Nea Paphos in the Hellenistic period (Maier and Karageorghis 1984: 230–231; Green 1990: 30, 125, 194; Młynarczyk 1990: 129–130).

In Nea Paphos, CCW comprises the most common class of fine pottery recovered at the excavations in all districts through the entire Hellenistic period (Table 1). It appears in a number of different forms and fabrics, possibly indicating its varied origin. The stylistic study has so far shown that the CCW frequency as well as the diversity in the shape of the vessels and macroscopic appearance of fabrics increased significantly in the Late Hellenistic period, which dates from the late second to the late first c. BCE.[2] In 58 BCE, the Romans annexed Cyprus, but the significant changes in the pottery assemblage reflecting the new political situation are seen in contexts dated after an earthquake, which destroyed the city in 17 or 15 BCE. In those contexts, in terms of fine ware pottery, CCW occurs rarely and only includes semi-coarse echinus bowls and plates with a rolled rim, while eastern sigillata is the predominant pottery class.

## The archaeological context

The ancient Agora in Nea Paphos comprised a square enclosed by porticoes from the east, south and west sides, which were built in the late second or the early first c. BCE. The excavations at the Agora have been carried

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[1] This study is part of a PhD research project focused on the characterisation and contextualisation of CCW in Paphos. In the framework of this project, a few thousands of CCW potsherds and whole vessels from two excavations in Paphos, the Agora and the Maloutena residential area, were studied macroscopically. As a result, 16 macroscopic groups (MG 1–MG 16) were defined, and 164 samples were selected for further chemical and petrographic analysis, see: Marzec 2017. In a previous paper (Marzec et al. 2018), MG 1 and MG 2 have been discussed. They date to the Early Hellenistic period (late fourth–ca. mid-second century BCE) and are represented by 35 samples, the majority of which was unearthed in the Maloutena residential area (33 out of 35 samples). The current paper presents the macroscopic groups: MG 9, MG 10, MG 11 and MG 12, dated to the Late Hellenistic period (late second–late first c. BCE) and represented by 53 samples (see Table 2) from one closed deposit in the Agora, which did not include any examples representing MG 1 and MG 2. Moreover, MGs discussed in the current paper are neither chemically nor petrographically related to MG 1 and MG 2.

[2] Marzec E, Kajzer M (forthcoming) Hellenistic Table Ware Pottery (from the late 4th to the 1st century BC). In: Papuci-Władyka E (ed.) PAPHOS AGORA 1. The results of the Jagiellonian University Interdisciplinary Research in Nea Paphos (2011–2015). Kraków

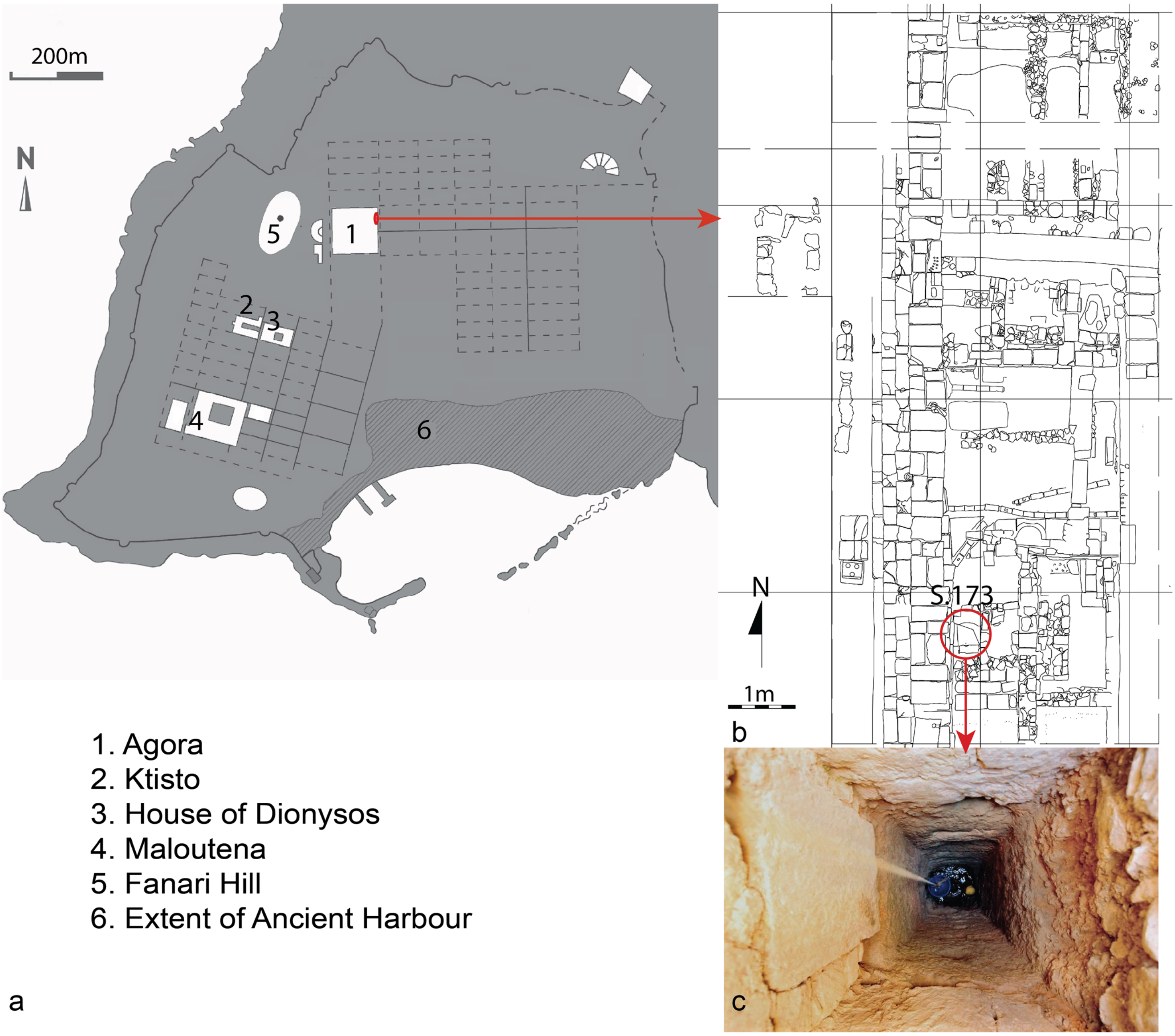

**Fig. 1** **a** Plan of Nea Paphos, based on J. Młynarczyk's research (1990) with modifications by the Paphos Agora Project. **b** Trench II, illustrated by K. Rosińska-Balik, 2014, © Paphos Agora Project. **c** The well, structure 173, photographed by R. Słaboński

out since 2011 in four trenches (I–IV).[3] One of them (Trench II) uncovered the area of the eastern portico, comprising a part of the crepidoma, the stylobate and rooms within the vicinity. The construction of the rooms dates to the times of Augustus, after the earthquake that hit the city in 17 or 15 BCE, but the presence of earlier layers in some parts of the trench suggests that the portico was originally built in the Late Hellenistic period. The Late Hellenistic closed deposit discussed in this paper was found in the well (Structure 173) discovered in Room 13 (Fig. 1). The well was partially carved into the bedrock. Its upper east side adjoined the crepidoma and the other three were constructed with limestone blocks. The well had a depth of 7 m and was filled with objects from top to bottom. Moreover, water was encountered at the depth of 5.95 m and excavation required pumping equipment. The deposit yielded numerous nearly complete vessels and thousands of pottery sherds. This assemblage comprises different categories of ceramics such as fine wares, plain wares, cooking wares and amphorae. The pottery found in the well deposit dates from the late second until the third quarter of the first c. BCE. However, the presence of Eastern Sigillata A form 23, Eastern Sigillata D forms P18A and P20, as well as a coin of Ptolemy of Cyprus (80–58 BCE) suggests that the deposition took place between the end of the first quarter and the beginning of the third quarter of the first c. BCE. There is no evidence of later contamination or disturbance. Other finds belonging to the deposit, such as metal objects, glass vessels,

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[3] Miszk Ł (forthcoming) Stratigraphy of the Agora. In: Papuci-Władyka E (ed.) PAPHOS AGORA 1. The results of the Jagiellonian University Interdisciplinary Research in Nea Paphos (2011–2015). Kraków

terracotta figurines and lamps, have confirmed this date.[4] Fine pottery of various wares and fabrics is the most abundant category of finds in this deposit. Apart from CCW, Eastern Sigillata A and Eastern Sigillata D, the assemblage also includes the so-called Red Slip and banded pottery.

## Methodology

The first stage of the research combined the macroscopic study of fabric and shape. The fabric examination was based on the classification of the ceramic assemblage into groups according to the following parameters: frequency, size and colour of inclusions, frequency, size and shape of voids, colour of the fresh break, fired core types (according to Gauß and Kiriatzi 2011: 408, Fig. 30), hardness, feel of the surface, texture of fresh break and colour of slip. The classification and description system adopted in this study were proposed by Orton and Hughes, and it is presented in *Pottery in Archaeology* (2013: 275–285). Fabrics were examined by naked eye and with a × 10 magnifying glass in natural light. Hardness was assessed through the use of fingernail and knife, while the feel of the surface was established through finger touch. The macroscopic examination of fabric was complemented by the typological analysis, which was undertaken exclusively on diagnostic sherds. It followed the functional classification proposed by S. Rotroff (1997) with some modifications.

The macroscopic analysis was carried out on nearly a thousand of individual CCW vessels, recovered in the well deposit. Based on the two variables (fabric and vessel shape), the assemblage was classified into eight macroscopic groups (MG). The sheer majority of CCW was associated with four of them, MG 9, MG 10, MG 11 and MG 12, which are assumed to represent the potential local production (Hayes 1991; Papuci-Władyka 1995). Fifty-three samples representing their variability were selected for laboratory analysis to test the macroscopic classification consistency and provide further evidence on the provenance and manufacturing technology of the four most common groups (Tables 2 and 3). Other four MGs, represented only by single vessels or few sherds and classified as imports, were not sampled as the research was focused on the local production.

All selected samples were subjected to refiring tests at the same temperature and under the same conditions (1000 °C, 1 h soaking time, oxidising conditions) in order to 'remove' colour variation introduced by firing rather than raw materials composition and to provide a more solid ground for the macroscopic grouping (Whitbread 1995: 390–391; Kiriatzi et al. 2011: 69–70). The colours of fully oxidised clay pastes and slips were recorded using the Munsell Soil Color Charts (1990) and compared directly with the sherds before refiring. Then, all samples were analysed through wavelength-dispersive X-ray fluorescence (WD-XRF) spectroscopy in order to characterise their elemental composition. The ceramic samples were carefully cleaned to remove any surface contamination and decoration layers and subsequently ground to a fine powder. Fused glass beads were prepared, using 1 g of the previously dried and then ignited sample and 6 g of a mixture of lithium metaborate/lithium tetraborate with lithium bromide as non-wetting agent. The analysis was carried out on a WD-XRF spectrometer, BRUKER S8-TIGER with a Rh excitation source, using a custom calibration based on 43 certified reference materials (Georgakopoulou et al. 2017). Twenty-six major and trace elements were determined: Na, Mg, Al, Si, P, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Rb, Sr, Y, Zr, Ba, La, Ce, Nd, Pb, and Th. Subsequently, the WD-XRF data were subjected to statistical multivariate analyses using the R software. The statistical treatment followed the approach proposed by J. Buxeda i Garrigós (1999). Based on the results of the refiring tests, macroscopic and elemental analysis, 15 samples representing the observed variation were selected for petrographic analysis. Covered standard thin sections were prepared and examined using a Zeiss Axioskop 40 polarising microscope at magnifications ranging between × 25 and × 500. The description followed an adjusted version of the description system proposed by Whitbread (1995).

Based on the combination of macroscopic and laboratory analyses, the relation between the MGs was defined and a final grouping was established. In order to provide more detailed information concerning surface treatment and firing regimes, ten samples, analysed already through thin section petrography, and representing variability observed in relation to surface treatment and firing, were chosen for scanning electron microscopy (SEM) (Tite and Maniatis 1975; Maniatis and Tite 1981). The fresh breaks of the selected samples were carbon-coated and examined with a FEI, Quanta Inspect D8334 SEM in secondary electron and backscattering mode. Semi-quantitative analysis for major elements was carried out using an attached energy-dispersive X-ray fluorescence spectrometer (EDS). Additionally, geological sampling was carried out in the area of Paphos in order to explore the availability and the characteristics of the locally available potential raw materials for pottery manufacture. Four geological samples were collected: alluvial sediments from the Ezousa river and Agriokalami stream, bentonite clay from Armou and clay rich sediment from excavations at the ancient Agora in Nea Paphos (Fig. 2). Four briquettes were formed from each sample. One briquette was left unfired and the others were fired for 1 h (soaking time) at 700 °C, 900 °C and 1100 °C, respectively, under

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[4] Papuci-Władyka E (ed.) (forthcoming) PAPHOS AGORA 1. The results of the Jagiellonian University Interdisciplinary Research in Nea Paphos (2011–2015). Kraków

**Table 2** Selected CCW specimens representing four MGs and type of analysis employed in the study

| MG | Sample | Form | Refiring 1000 °C | WD-XRF | Thin section petrography | SEM |
|---|---|---|---|---|---|---|
| 9 / *n* = 18 | A.14 | Jug with cylindrical neck and ovoid body | √ | √ | √ | |
| | A.18 | Plate with rolled rim | √ | √ | √ | √ |
| | A.19 | Plate with rolled rim | √ | √ | | |
| | A.30 | Plate with rolled rim | √ | √ | | |
| | A.36 | Jug with pear-shaped body | √ | √ | | |
| | A.37 | Lagynoids | √ | √ | | |
| | A.40 | Jug with funnel-shaped mouth and globular body | √ | √ | | |
| | A.47 | Jar with two handles | √ | √ | | |
| | A.50 | Echinus bowl | √ | √ | | |
| | A.51 | Echinus bowl | √ | √ | | |
| | A.53 | Plate with rolled rim | √ | √ | | |
| | A.54 | Echinus bowl | √ | √ | | |
| | A.56 | Plate with rolled rim | √ | √ | | |
| | A.61 | Echinus bowl | √ | √ | | |
| | A.63 | Large plate with rolled rim | √ | √ | √ | √ |
| | A.65 | Large echinus bowl | √ | √ | | |
| | A.64 | Plate with rolled rim | √ | √ | √ | |
| | A.69 | Echinus bowl | √ | √ | √ | √ |
| 10 / *n* = 10 | A.12 | In-turned rim bowl | √ | √ | √ | |
| | A.15 | Large echinus bowl | √ | √ | | |
| | A.16 | Bi-conical jug | √ | √ | | |
| | A.17 | Echinus bowl | √ | √ | | |
| | A.21 | Plate with rolled rim | √ | √ | √ | √ |
| | A.41 | Jug with cylindrical neck and ovoid body | √ | √ | | |
| | A.42 | Large echinus bowl | √ | √ | √ | √ |
| | A.43 | Echinus bowl | √ | √ | | |
| | A.48 | Fishplate with overhanging rim | √ | √ | | |
| | A.49 | Echinus bowl | √ | √ | | |
| 11 / *n* = 17 | A.03 | Echinus bowl | √ | √ | √ | |
| | A.05 | Platter | √ | √ | | |
| | A.08 | Plate with rolled rim | √ | √ | | |
| | A.22 | Plate with rolled rim | √ | √ | | |
| | A.23 | Plate with rolled rim | √ | √ | | |
| | A.24 | Platter | √ | √ | √ | √ |
| | A.38 | Large plate with rolled rim | √ | √ | √ | √ |
| | A.39 | Jug with trefoil-mouth | √ | √ | | |
| | A.44 | Jug with cylindrical neck and ovoid body | √ | √ | √ | √ |
| | A.45 | Plate with rolled rim | √ | √ | | |
| | A.57 | Echinus bowl | √ | √ | | |
| | A.58 | Hemispherical cup | √ | √ | | |
| | A.59 | Echinus bowl | √ | √ | | |
| | A.60 | Echinus bowl | √ | √ | | |
| | A.62 | Plate with rolled rim | √ | √ | | |
| | A.66 | Large echinus bowl | √ | √ | √ | |
| | A.68 | Echinus bowl | √ | √ | | |

**Table 2** (continued)

| MG | Sample | Form | Refiring 1000 °C | WD-XRF | Thin section petrography | SEM |
|---|---|---|---|---|---|---|
| 12<br>/<br>*n* = 8 | A.07 | Lekane | √ | √ | √ | √ |
| | A.09 | Large plate with rolled rim | √ | √ | | |
| | A.10 | Large plate with rolled rim | √ | √ | | |
| | A.13 | Plate with rolled rim | √ | √ | | |
| | A.29 | Platter | √ | √ | | |
| | A.46 | Echinus bowl | √ | √ | √ | √ |
| | A.52 | Echinus bowl | √ | √ | | |
| | A.67 | Plate with rolled rim | √ | √ | | |

oxidising conditions using a muffle furnace. All fired briquettes were examined through thin section petrography, additionally those that were fired at 700 °C and 900 °C were analysed by WD-XRF (methodology as in Kiriatzi et al. 2011).

## Geology

The area of Paphos is drained by three major rivers, the Ezousa, Xeropotamos and Dhiarizos, which have their sources in the Troodos Mountains (Fig. 2). The rocks of the Paphos area are associated with three geological formations. The Troodos Ophiolite complex consisting of ultramafic rocks is exposed in the highlands, north and east from Paphos. The Mamonia complex crops out in the vicinity of the city and includes the oldest sedimentary and volcanic rocks in this part of Cyprus, as well as ultramafic and mafic plutonic rocks, and metamorphic rocks. The Circum Troodos Sedimentary Succession is built with the autochthonous sediments and is divided into several formations. The oldest sediments in this zone are of volcanoclastic origin, rich in Campanian bentonitic clays. The rest of the Paphos region, including the city of Paphos, lie directly on Quaternary sediments, overlying the Circum Troodos Sedimentary Succession. They are composed of biocalcarenites, sandstones, sandy marls, conglomerates, silts, clays and gravels (Malpas and Xenophontos 1987; GSD 1995; Silantyev et al. 2005a, b).

## Results and discussion

As above-mentioned, the majority of the CCW vessels found in the Late Hellenistic well deposit were classified into four MGs (Fig. 3). These MGs seem to be similar to each other in terms of vessel shape and style, but they were separated due to fabric variation related to the size and frequency of inclusions, colour, hardness, and the feel of the surface. MG 9 is characterised by a fine and hard fabric with a smooth feel of the surface. In contrast, the soft fabric and the powdery feel of the surface are two distinguishing features of MG 10. It seems that vessels assigned to this MG are related to the so-called *Pink Powdery Ware* known from the excavations on Geronisos Island, which is located 18 km north of Paphos (Młynarczyk 2005, 2010). MG 11 has a hard, pink or brown fabric with a smooth feel of the surface. The vessels are fine to semi-coarse with frequent white inclusions and lime popping. The fabric of vessels assigned to MG 12 is also hard with frequent white inclusions and lime popping, but it is characterised by a rough feel of the surface and lighter colours of the fresh break. Table 3 provides the detailed characterisation of the MGs and presents their distinctive features.

The shape analysis indicates the presence of 23 forms representing the discussed MGs in the macroscopically studied deposit. The entire assemblage is represented by the following functional categories: drinking cups, other vessels for wine service, vessels for food service and vessels for other purposes (Table 4). It is important to note that echinus bowls (drinking cups) and plates with a rolled rim (vessels for food service) are the most common in the deposit and appear in all MGs. Among other vessels, various types of jugs are common, mainly in relation to MG 9. Other shapes that are not very common and have not been included in the sample selection are lids, rounded-mouth juglets, olpai, strainer-jugs, kantharoid skyphoi and fusiform unguentaria.

All selected 53 samples were subjected to refiring tests. After refiring, the colour of the fresh break and slip, within each MG and the whole assemblage, became more homogenous. However, differences were still visible. The refired chips representing MG 9 and MG 11 show very similar range of body colours in the fresh break: pink (7.5YR 7/4, 8/4), reddish yellow (5YR 6/6) and yellowish red (5YR 5/6). MG 11 contains a few samples with a very pale brown (10YR 7/4) colour of body. This colour was also observed in the fresh breaks of all samples classified to MG 12 and of a few samples of MG

**Table 3** The characterisation of the four MGs discussed here. The definition of terms used in the table: frequency: rare—less than 2%, few—2–15%, common—15–30%; frequent—30–50%, size: fine—smaller than 0.25 mm, medium—0.25–0.5 mm, coarse—0.5–1 mm; hardness: soft—can be easily scratched with a fingernail, hard—can be scratched with a knife; feel of surface: smooth—no irregularities can be felt; powdery—leaves powder on the finger; rough—with irregularities; texture of fresh break: smooth—flat, without ripple marks, hackly—with more inclusions; large and angular irregularities. The descriptions follow the system proposed by Orton and Hughes (2013: 277–282); fired core types according to Gauß and Kiriatzi (2011: Fig. 30); colours were recorded using the Munsell Soil Color Charts (1990)

| | MG 9 | MG 10 | MG 11 | MG 12 |
|---|---|---|---|---|
| Frequency, size and colour of inclusions visible at the fresh break | Rare, fine to medium<br>- Common fine to medium white<br>- Common fine black<br>- Common fine to medium red<br>- Few fine sparkling | Rare to few, fine to medium<br>- Common fine to medium white<br>- Few to common fine to medium black<br>- Few to common fine to medium red<br>- Rare fine sparkling | Rare to few, fine to coarse<br>- Frequent fine to coarse white<br>- Common to frequent fine black<br>- Rare to few fine red<br>- Rare fine sparkling | Few, fine to coarse<br>- Frequent fine to medium white<br>- Common to frequent fine to medium black<br>- Common fine to coarse red |
| Frequency, size and shape of voids visible at the fresh break | Rare<br>- Frequent to few fine to medium rounded<br>- Frequent coarse thin, rather angular and elongated shape | Rare<br>- Frequent fine to coarse rounded<br>- Frequent fine to coarse thin, rather angular and elongated shape | Rare<br>- Frequent fine to coarse rounded<br>- Frequent fine to coarse thin, rather angular and elongated shape | Rare to few<br>- Frequent fine to coarse rounded<br>- Frequent fine to coarse thin, rather angular and elongated shape |
| Colour of the fresh break | Pink (5YR 7/4,7.5YR 7/4, 8/4), light reddish brown (5YR 6/4), very pale brown (10YR 7/3), reddish yellow (5YR 6/6) | White (10YR 8/2), light grey (10YR 7/2), very pale brown (10YR 7/3), pink (7.5YR 7/4),light reddish brown (5YR 6/4), light yellowish brown (10YR 6/4) | Pink (7.5YR 8/4), light reddish brown (5YR 6/4), reddish yellow (7.5YR 7/6), very pale brown (10YR 7/3, 7/4), light grey (10YR 7/1) | White (10YR 8/2),<br>Very pale brown (8/3, 7/3), pink (7.5 YR 7/4) |
| Fired core | (1) Fully oxidised<br>(2) Not fully oxidised<br>(8) Not fully reduced | (1) Fully oxidised<br>(6) Changing conditions<br>(9, 10) Not fully reduced | (1) Fully oxidised<br>(2) Not fully oxidised<br>(9) Not fully reduced | (1) Fully oxidised<br>(4) Not fully oxidised<br>(10) Not fully reduced |
| Hardness | Hard | Soft | Hard | Hard |
| Feel of surface | Smooth | Powdery | Smooth | Rough |
| Texture of fresh break | Smooth | Smooth | Smooth | Hackly |
| Colour of slip | Red (2.5YR 4/8, 5/6, 5/8), yellowish red (5YR 5/6), brown (7.5YR 5/4); zones across the surface: red (2.5YR 4/2), reddish black (2.5YR 4/6), reddish brown (5YR 4/3), black (2.5YR 2.5/0) | Dark grey (2.5YR 4/0), weak red (2.5YR 4/2), strong brown (7.5YR 4/6), reddish brown (5YR 4/4), dark reddish grey (5YR 4/2), yellowish red (5YR 5/6, 6/6) | Red (2.5YR 5/6), dark grey (5YR 4/1), reddish brown (5YR 5/4), very dark grey (7.5YR 3/0), reddish yellow (7.5YR 6/6), dark greyish brown (10YR 4/2) | Brown (7.5YR 5/4), dark grey (7.5YR 4/0), yellowish red (5YR 5/6), pale yellow (5Y 7/3), yellowish brown (10YR 5/4) |

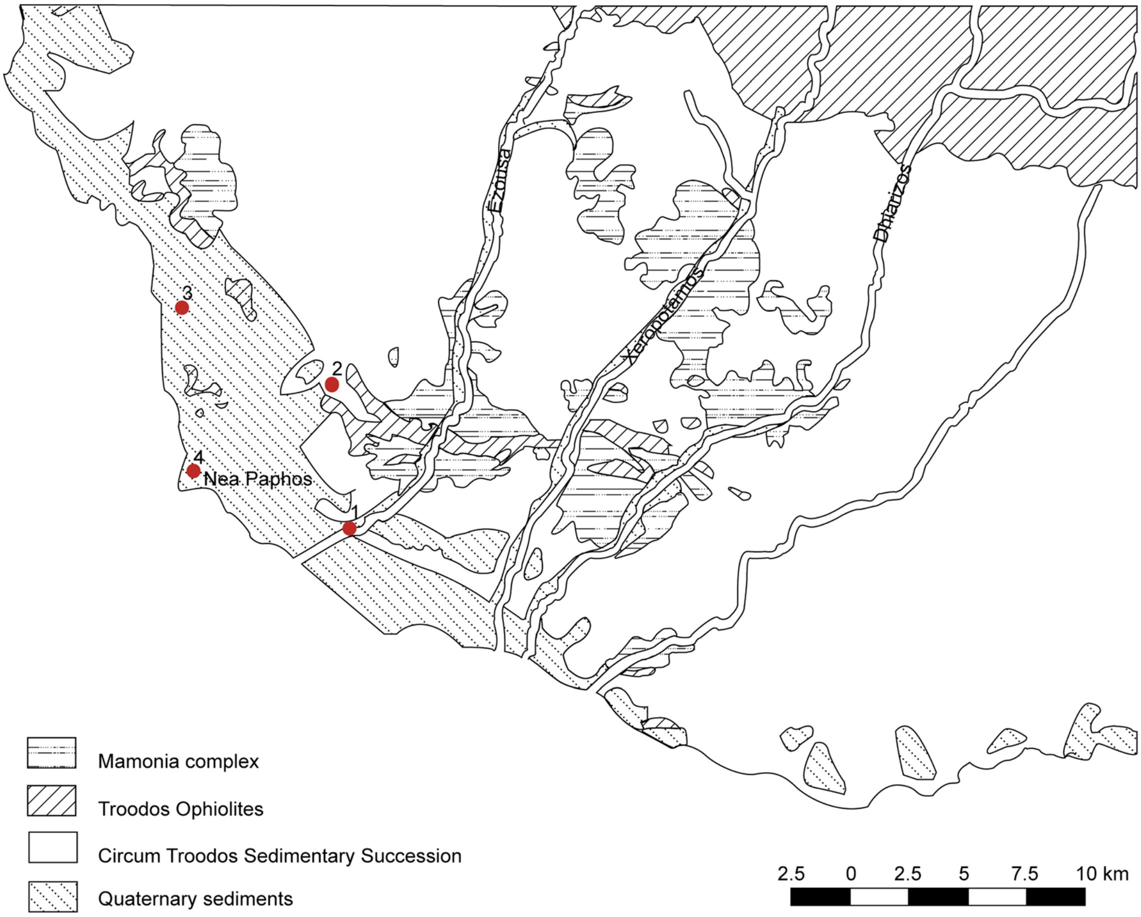


**Fig. 2** The geological map of Paphos (based on GSD 1995). The locations of geological samples are indicated with red dots and numbers: 1 sediment from the Ezousa river, 2 bentonite clay from Armou, 3 sediment from Agriokalami stream, and 4 clay rich sediment from excavations at the ancient Agora in Nea Paphos

10. The colour of the slips is homogenous across all MGs; it is represented by various hues of red (2.5YR 4/6, 4/8, 5/6) or reddish brown (2.5YR 4/4, 5/4; 5YR 5/3, 5/4), while the black or very dark grey zones seen on the surface of some vessels in most cases disappeared upon refiring.

The dataset with the elemental compositions of the assemblage consisting of 53 samples (Table 5) was analysed statistically. The compositional variation matrix for 26 elements was calculated in order to assess the total variation and the variability of each element (Buxeda i Garrigós 1999). The value of the total

**Fig. 3** Photos of echinus bowls representing the four main MGs identified in the current assemblage: **a** sample A.61 (MG 9), **b** sample A.43 (MG 10), **c** sample M.60 (MG 11), and **d** sample A.46 (MG 12)

**Table 4** The typological classification of the vessels representing the four MGs and the petrographic subgroups (PG 1A and PG 1B) discussed in this study

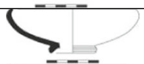
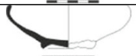
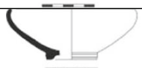
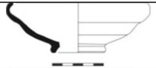
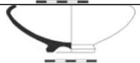
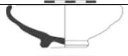
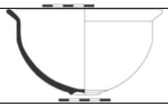
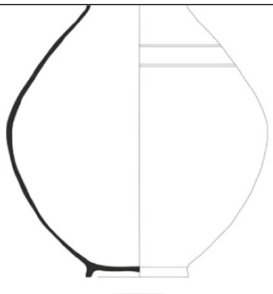
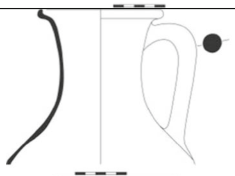
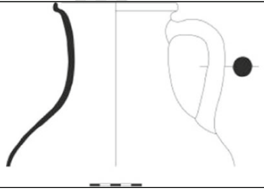
| Sample | Form | Illustration | MG | PG |
|---|---|---|---|---|
| **Drinking cups** | | | | |
| A.03 | echinus bowl |  | 11 | 1A |
| A.17 | echinus bowl |  | 10 | |
| A.43 | echinus bowl |  | 10 | |
| A.46 | echinus bowl |  | 12 | 1B |
| A.49 | echinus bowl |  | 10 | |
| A.50 | echinus bowl |  | 9 | |
| A.51 | echinus bowl |  | 9 | |
| A.52 | echinus bowl |  | 12 | |
| A.54 | echinus bowl |  | 9 | |
| A.57 | echinus bowl |  | 11 | |
| A.59 | echinus bowl |  | 11 | |
| A.60 | echinus bowl |  | 11 | |
| A.61 | echinus bowl |  | 9 | |
| A.68 | echinus bowl |  | 11 | |
| A.69 | echinus bowl |  | 9 | 1A |
| A.58 | hemispherical cup |  | 11 | |
| **Other Vessels for wine service** | | | | |
| A.14 | jug with cylindrical neck and ovoid body |  | 9 | 1B |
| A.41 | jug with cylindrical neck and ovoid body |  | 10 | |
| A.44 | jug with cylindrical neck and ovoid body |  | 11 | 1B |

**Table 4** (continued)

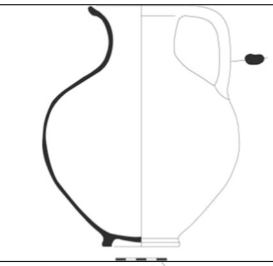
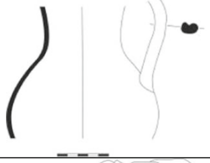
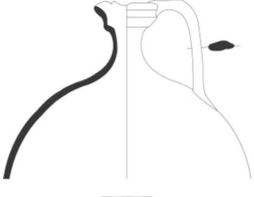
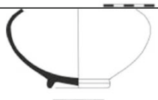
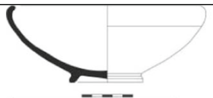
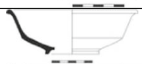
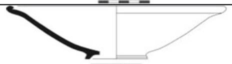
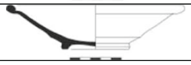
| Sample | Form | Illustration | MG | PG |
|---|---|---|---|---|
| A.40 | jug with funnel-shaped mouth and globular body |  | 9 | |
| A.36 | jug with pear-shaped body |  | 9 | |
| A.39 | jug with trefoil-mouth |  | 11 | |
| A.37 | lagynoids |  | 9 | |
| A.16 | bi-conical jug |  | 10 | |
| | | **Vessels for food service** | | |
| A.15 | large echinus bowl |  | 10 | |
| A.42 | large echinus bowl |  | 10 | 1B |
| A.66 | large echinus bowl |  | 11 | 1A |
| A.65 | large echinus bowl |  | 9 | |
| A.12 | in-turned rim bowl |  | 10 | 1A |
| A.08 | plate with rolled rim |  | 11 | |
| A.13 | plate with rolled rim |  | 12 | |
| A.18 | plate with rolled rim |  | 9 | 1B |
| A.19 | plate with rolled rim |  | 9 | |
| A.21 | plate with rolled rim |  | 10 | 1A |
| A.22 | plate with rolled rim |  | 11 | |

**Table 4** (continued)

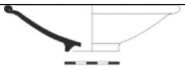
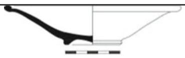
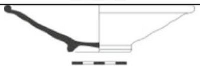
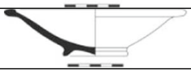
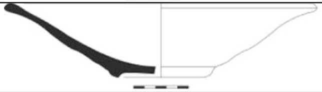
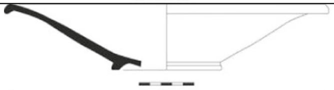
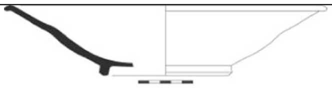
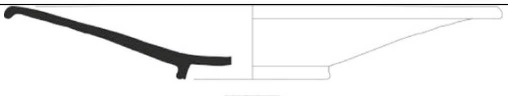
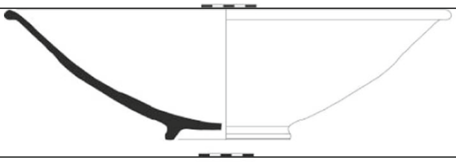
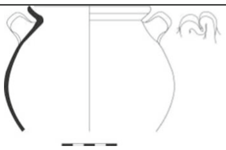
| Sample | Form | Illustration | MG | PG |
|---|---|---|---|---|
| A.23 | plate<br>with rolled rim |  | 11 | |
| A.30 | plate<br>with rolled rim |  | 9 | |
| A.45 | plate<br>with rolled rim |  | 11 | |
| A.53 | plate<br>with rolled rim |  | 9 | |
| A.56 | plate<br>with rolled rim |  | 9 | |
| A.62 | plate<br>with rolled rim |  | 11 | |
| A.64 | plate<br>with rolled rim |  | 9 | 1B |
| A.67 | plate<br>with rolled rim |  | 12 | |
| A.10 | large plate<br>with rolled rim |  | 12 | |
| A.09 | large plate<br>with sloping<br>rim |  | 12 | |
| A.38 | large plate<br>with sloping<br>rim |  | 11 | 1A |
| A.63 | large plate<br>with sloping<br>rim |  | 9 | 1A |
| A.48 | plate with<br>overhanging<br>rim |  | 10 | |
| A.05 | platter |  | 11 | |
| A.29 | platter |  | 12 | |
| A.24 | platter |  | 11 | 1A |
| A.07 | lekane |  | 12 | 1A |
| **Vessels for other purposes** | | | | |
| A.47 | jar<br>with two<br>handles |  | 9 | |

**Table 5** Chemical compositions of 53 samples discussed in this paper; oxides, LOI (loss on ignition) and sum are expressed in wt% and elements in ppm

| Sample | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | P | $K_2O$ | CaO | $TiO_2$ | V | Cr | Mn | $Fe_2O_3$ | Co | Ni | Cu | Zn | Rb | Sr | Y | Zr | Ba | La | Ce | Nd | Pb | Th | LOI | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A03 | 1.60 | 4.27 | 13.83 | 49.56 | 536 | 1.28 | 13.73 | 0.70 | 173 | 94 | 947 | 8.41 | 27 | 65 | 153 | 104 | 42 | 556 | 20 | 77 | 296 | 22 | 29 | 12 | 53 | 3 | 6.34 | 100.05 |
| A05 | 0.86 | 3.33 | 12.82 | 50.66 | 1079 | 1.69 | 16.07 | 0.68 | 105 | 96 | 1108 | 6.32 | 24 | 89 | 118 | 94 | 66 | 590 | 26 | 114 | 710 | 37 | 58 | 29 | 31 | 6 | 6.75 | 99.61 |
| A07 | 1.80 | 4.75 | 13.32 | 50.48 | 773 | 1.60 | 14.67 | 0.77 | 130 | 204 | 899 | 8.59 | 26 | 111 | 112 | 112 | 46 | 814 | 20 | 102 | 204 | 8 | 25 | 12 | 33 | 5 | 3.58 | 99.92 |
| A08 | 0.77 | 3.44 | 14.35 | 57.65 | 811 | 1.84 | 10.72 | 0.75 | 138 | 126 | 1080 | 6.95 | 26 | 100 | 87 | 95 | 73 | 495 | 27 | 127 | 439 | 34 | 64 | 25 | 23 | 8 | 3.22 | 100.08 |
| A09 | 0.99 | 2.90 | 11.82 | 47.69 | 916 | 1.52 | 19.44 | 0.59 | 102 | 102 | 1265 | 6.05 | 24 | 81 | 118 | 90 | 52 | 804 | 23 | 105 | 451 | 21 | 36 | 19 | 25 | 7 | 8.39 | 99.82 |
| A10 | 0.95 | 3.29 | 12.54 | 51.48 | 928 | 1.56 | 16.70 | 0.61 | 113 | 115 | 1385 | 6.77 | 25 | 98 | 122 | 79 | 53 | 632 | 21 | 104 | 374 | 21 | 35 | 28 | 38 | 5 | 5.62 | 99.94 |
| A12 | 0.81 | 2.80 | 10.93 | 46.56 | 907 | 1.67 | 18.63 | 0.60 | 123 | 112 | 886 | 5.74 | 24 | 71 | 138 | 60 | 43 | 1283 | 23 | 100 | 717 | 26 | 47 | 13 | 234 | 10 | 11.33 | 99.54 |
| A13 | 1.20 | 4.21 | 12.30 | 44.26 | 882 | 1.47 | 19.62 | 0.67 | 104 | 148 | 1037 | 7.06 | 24 | 86 | 228 | 104 | 50 | 816 | 23 | 96 | 306 | 23 | 33 | 20 | 63 | 7 | 8.55 | 99.73 |
| A14 | 0.68 | 3.24 | 14.57 | 56.81 | 758 | 2.24 | 10.83 | 0.79 | 116 | 112 | 855 | 6.86 | 26 | 102 | 90 | 82 | 87 | 627 | 25 | 202 | 513 | 32 | 62 | 27 | 97 | 10 | 3.36 | 99.77 |
| A15 | 0.84 | 2.79 | 10.45 | 47.64 | 1439 | 1.31 | 17.32 | 0.60 | 112 | 90 | 1263 | 5.63 | 23 | 80 | 96 | 93 | 45 | 689 | 23 | 98 | 468 | 22 | 46 | 25 | 26 | 8 | 12.32 | 99.35 |
| A16 | 1.03 | 3.11 | 11.65 | 50.99 | 818 | 1.73 | 15.16 | 0.65 | 109 | 85 | 1201 | 6.36 | 23 | 67 | 119 | 68 | 51 | 999 | 23 | 108 | 525 | 26 | 42 | 15 | 370 | 8 | 8.76 | 99.90 |
| A17 | 0.97 | 4.48 | 12.61 | 53.58 | 525 | 1.67 | 8.25 | 0.64 | 124 | 124 | 837 | 7.08 | 26 | 103 | 197 | 94 | 43 | 744 | 20 | 102 | 239 | 15 | 33 | 24 | 216 | 7 | 9.57 | 99.19 |
| A18 | 0.61 | 2.86 | 12.97 | 51.17 | 810 | 1.68 | 12.91 | 0.62 | 108 | 130 | 945 | 6.28 | 25 | 84 | 108 | 103 | 57 | 810 | 24 | 104 | 613 | 29 | 45 | 24 | 23 | 7 | 10.37 | 99.88 |
| A19 | 1.25 | 3.71 | 13.97 | 58.35 | 814 | 1.86 | 8.94 | 0.71 | 144 | 103 | 1160 | 7.30 | 28 | 86 | 158 | 115 | 62 | 533 | 26 | 120 | 341 | 28 | 54 | 28 | 91 | 7 | 3.50 | 99.97 |
| A21 | 1.03 | 3.60 | 14.39 | 52.44 | 1056 | 1.96 | 12.90 | 0.83 | 148 | 130 | 954 | 7.62 | 26 | 86 | 111 | 107 | 64 | 584 | 25 | 116 | 299 | 27 | 50 | 24 | 30 | 7 | 4.65 | 99.81 |
| A22 | 1.12 | 3.63 | 13.81 | 52.83 | 895 | 1.76 | 13.85 | 0.74 | 115 | 119 | 1161 | 7.30 | 28 | 91 | 124 | 107 | 66 | 559 | 26 | 119 | 495 | 24 | 51 | 26 | 32 | 7 | 4.63 | 100.06 |
| A23 | 0.60 | 3.03 | 12.06 | 49.61 | 1117 | 1.80 | 16.58 | 0.62 | 119 | 128 | 925 | 5.74 | 21 | 91 | 109 | 112 | 66 | 841 | 22 | 111 | 722 | 37 | 60 | 24 | 28 | 5 | 9.34 | 99.83 |
| A24 | 0.96 | 3.76 | 14.23 | 57.14 | 724 | 1.92 | 10.04 | 0.72 | 132 | 111 | 1237 | 7.20 | 27 | 76 | 110 | 91 | 69 | 604 | 24 | 114 | 443 | 30 | 50 | 25 | 111 | 7 | 3.65 | 100.02 |
| A29 | 1.27 | 4.55 | 11.39 | 43.13 | 1082 | 1.40 | 21.36 | 0.65 | 115 | 178 | 916 | 6.76 | 20 | 195 | 108 | 101 | 46 | 817 | 21 | 88 | 346 | 9 | 33 | 12 | 38 | 6 | 8.97 | 99.88 |
| A30 | 0.59 | 2.78 | 11.80 | 45.44 | 864 | 2.01 | 18.63 | 0.60 | 108 | 102 | 1211 | 5.55 | 24 | 111 | 123 | 128 | 66 | 1019 | 25 | 110 | 1246 | 38 | 60 | 23 | 50 | 7 | 12.16 | 100.10 |
| A36 | 0.84 | 3.89 | 15.26 | 56.26 | 923 | 2.05 | 9.26 | 0.75 | 144 | 112 | 1274 | 7.66 | 29 | 95 | 146 | 136 | 75 | 575 | 24 | 117 | 443 | 26 | 52 | 36 | 51 | 12 | 3.08 | 99.48 |
| A37 | 0.84 | 3.68 | 14.91 | 57.60 | 908 | 1.90 | 9.99 | 0.76 | 130 | 117 | 1114 | 7.38 | 29 | 92 | 111 | 105 | 73 | 431 | 25 | 125 | 417 | 25 | 55 | 26 | 28 | 9 | 2.39 | 99.82 |
| A38 | 1.68 | 4.24 | 12.92 | 47.68 | 812 | 1.51 | 15.01 | 0.72 | 187 | 140 | 905 | 7.81 | 28 | 65 | 101 | 100 | 40 | 940 | 20 | 92 | 358 | 11 | 24 | 12 | 52 | 4 | 8.01 | 99.99 |
| A39 | 0.68 | 3.60 | 12.85 | 46.99 | 971 | 1.76 | 18.30 | 0.63 | 138 | 111 | 990 | 6.34 | 26 | 98 | 116 | 107 | 67 | 597 | 23 | 102 | 662 | 26 | 51 | 29 | 24 | 8 | 8.01 | 99.57 |
| A40 | 0.85 | 3.24 | 14.24 | 53.73 | 1329 | 1.88 | 9.82 | 0.72 | 139 | 103 | 943 | 7.07 | 25 | 85 | 147 | 116 | 62 | 495 | 23 | 119 | 371 | 26 | 59 | 22 | 33 | 10 | 7.66 | 99.62 |
| A41 | 0.77 | 3.42 | 13.78 | 49.61 | 1300 | 2.04 | 16.82 | 0.71 | 83 | 126 | 964 | 6.46 | 26 | 120 | 97 | 106 | 75 | 764 | 25 | 126 | 1128 | 28 | 63 | 31 | 34 | 8 | 5.48 | 99.60 |
| A42 | 0.83 | 3.14 | 12.91 | 53.29 | 901 | 1.95 | 14.07 | 0.69 | 119 | 105 | 1069 | 6.31 | 28 | 87 | 107 | 69 | 70 | 1019 | 24 | 119 | 976 | 32 | 57 | 22 | 107 | 7 | 6.26 | 99.93 |
| A43 | 0.91 | 3.45 | 14.07 | 54.24 | 1077 | 1.99 | 13.40 | 0.74 | 148 | 116 | 1667 | 7.08 | 28 | 103 | 113 | 81 | 73 | 848 | 24 | 125 | 668 | 29 | 57 | 28 | 225 | 11 | 3.06 | 99.48 |
| A44 | 0.61 | 2.67 | 11.24 | 48.45 | 1016 | 1.48 | 18.75 | 0.62 | 108 | 101 | 1031 | 5.51 | 23 | 98 | 86 | 101 | 60 | 635 | 26 | 106 | 643 | 31 | 49 | 22 | 25 | 10 | 10.39 | 100.13 |
| A46 | 0.62 | 2.58 | 10.18 | 36.85 | 715 | 1.37 | 13.56 | 0.55 | 93 | 98 | 740 | 4.88 | 19 | 69 | 73 | 76 | 55 | 533 | 20 | 92 | 414 | 30 | 46 | 13 | 44 | 5 | 29.18 | 100.08 |
| A47 | 0.95 | 3.75 | 14.77 | 54.86 | 3144 | 1.95 | 9.62 | 0.73 | 198 | 145 | 935 | 8.80 | 28 | 135 | 164 | 102 | 63 | 618 | 22 | 111 | 520 | 30 | 56 | 23 | 40 | 8 | 3.05 | 99.11 |
| A48 | 1.09 | 3.61 | 12.31 | 51.49 | 762 | 1.86 | 14.33 | 0.67 | 88 | 113 | 1104 | 6.08 | 25 | 98 | 165 | 71 | 62 | 984 | 23 | 128 | 432 | 28 | 64 | 28 | 300 | 10 | 7.47 | 99.36 |
| A49 | 0.62 | 2.97 | 12.72 | 49.05 | 970 | 2.06 | 17.62 | 0.65 | 118 | 120 | 889 | 5.83 | 22 | 91 | 101 | 76 | 74 | 1201 | 26 | 117 | 1230 | 39 | 66 | 27 | 166 | 8 | 8.01 | 100.06 |
| A50 | 0.56 | 2.98 | 12.44 | 48.72 | 785 | 1.54 | 16.01 | 0.59 | 106 | 99 | 928 | 5.97 | 23 | 84 | 94 | 97 | 59 | 762 | 21 | 99 | 623 | 22 | 44 | 26 | 28 | 8 | 10.63 | 99.84 |
| A51 | 0.75 | 2.78 | 11.51 | 49.65 | 766 | 1.41 | 15.18 | 0.64 | 104 | 90 | 1059 | 5.61 | 23 | 84 | 93 | 98 | 55 | 581 | 23 | 112 | 475 | 30 | 50 | 27 | 33 | 6 | 11.86 | 99.76 |
| A52 | 1.33 | 4.38 | 9.42 | 37.41 | 663 | 0.94 | 22.68 | 0.53 | 124 | 153 | 785 | 6.00 | 20 | 74 | 111 | 89 | 23 | 832 | 18 | 63 | 147 | 7 | 17 | 13 | 14 | 7 | 16.65 | 99.64 |
| A53 | 1.86 | 4.84 | 14.29 | 48.74 | 949 | 1.61 | 11.92 | 0.96 | 204 | 107 | 941 | 9.77 | 30 | 58 | 106 | 113 | 40 | 616 | 20 | 86 | 106 | 11 | 22 | 20 | 47 | 3 | 5.32 | 99.65 |
| A54 | 0.79 | 3.20 | 13.89 | 54.12 | 617 | 1.76 | 9.63 | 0.70 | 129 | 95 | 924 | 6.85 | 24 | 82 | 281 | 111 | 59 | 487 | 23 | 114 | 390 | 24 | 53 | 29 | 75 | 9 | 8.46 | 99.74 |
| A56 | 0.78 | 3.04 | 13.50 | 57.36 | 877 | 2.06 | 10.52 | 0.73 | 130 | 107 | 1172 | 6.31 | 26 | 74 | 131 | 83 | 76 | 840 | 26 | 134 | 569 | 29 | 53 | 30 | 141 | 5 | 5.05 | 99.80 |
| A57 | 0.96 | 3.09 | 12.06 | 51.96 | 973 | 1.72 | 14.95 | 0.66 | 116 | 131 | 1336 | 5.74 | 34 | 75 | 83 | 63 | 53 | 1203 | 23 | 109 | 830 | 15 | 44 | 19 | 98 | 7 | 8.35 | 100.00 |
| A58 | 1.15 | 3.61 | 14.43 | 58.88 | 1277 | 1.71 | 8.41 | 0.74 | 145 | 107 | 1384 | 7.55 | 28 | 94 | 113 | 113 | 59 | 415 | 24 | 116 | 350 | 26 | 38 | 24 | 27 | 8 | 2.20 | 99.11 |
| A59 | 0.81 | 3.34 | 14.50 | 57.67 | 977 | 1.91 | 10.24 | 0.78 | 128 | 159 | 1160 | 7.05 | 28 | 102 | 96 | 98 | 74 | 406 | 25 | 133 | 379 | 29 | 58 | 30 | 26 | 8 | 3.01 | 99.70 |
| A60 | 0.67 | 3.57 | 14.96 | 55.89 | 814 | 2.06 | 12.36 | 0.74 | 123 | 145 | 911 | 7.27 | 27 | 104 | 105 | 94 | 79 | 684 | 22 | 125 | 711 | 30 | 53 | 27 | 47 | 8 | 1.93 | 99.87 |

**Table 5** (continued)

| Sample | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | P | $K_2O$ | CaO | $TiO_2$ | V | Cr | Mn | $Fe_2O_3$ | Co | Ni | Cu | Zn | Rb | Sr | Y | Zr | Ba | La | Ce | Nd | Pb | Th | LOI | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A61 | 1.00 | 3.32 | 10.33 | 40.36 | 741 | 1.14 | 19.18 | 0.54 | 133 | 96 | 849 | 5.85 | 20 | 60 | 99 | 96 | 38 | 643 | 20 | 78 | 259 | 15 | 34 | 16 | 25 | 3 | 17.58 | 99.62 |
| A62 | 1.00 | 3.37 | 13.68 | 53.21 | 1523 | 1.80 | 13.63 | 0.77 | 111 | 145 | 1078 | 7.03 | 23 | 99 | 117 | 97 | 67 | 601 | 28 | 125 | 558 | 24 | 52 | 31 | 41 | 8 | 4.60 | 99.77 |
| A63 | 1.01 | 4.45 | 11.91 | 48.28 | 642 | 1.39 | 13.23 | 0.62 | 126 | 160 | 968 | 6.53 | 23 | 83 | 85 | 86 | 43 | 589 | 23 | 98 | 474 | 20 | 38 | 14 | 12 | 6 | 11.57 | 99.34 |
| A64 | 0.82 | 2.84 | 9.42 | 35.09 | 1465 | 1.04 | 26.48 | 0.49 | 108 | 73 | 1083 | 5.34 | 20 | 58 | 115 | 92 | 36 | 992 | 20 | 77 | 626 | 22 | 27 | 11 | 17 | 4 | 18.03 | 100.04 |
| A65 | 0.77 | 3.19 | 12.22 | 45.63 | 936 | 1.52 | 15.79 | 0.59 | 131 | 101 | 949 | 6.39 | 25 | 89 | 122 | 122 | 50 | 828 | 21 | 94 | 598 | 26 | 38 | 23 | 35 | 6 | 13.35 | 99.88 |
| A66 | 1.41 | 4.03 | 13.61 | 51.63 | 983 | 1.89 | 12.94 | 0.97 | 144 | 177 | 1198 | 8.19 | 27 | 77 | 120 | 111 | 49 | 656 | 24 | 110 | 197 | 17 | 41 | 19 | 26 | 6 | 4.77 | 99.83 |
| A67 | 1.43 | 4.03 | 12.62 | 48.49 | 887 | 2.11 | 15.12 | 1.06 | 128 | 147 | 866 | 7.93 | 24 | 69 | 109 | 68 | 42 | 1253 | 19 | 112 | 512 | 14 | 39 | 12 | 424 | 6 | 6.80 | 100.06 |
| A68 | 0.95 | 2.61 | 10.40 | 43.89 | 1175 | 1.18 | 18.67 | 0.53 | 107 | 108 | 1070 | 5.54 | 20 | 127 | 124 | 100 | 47 | 614 | 20 | 95 | 624 | 14 | 38 | 16 | 24 | 8 | 15.54 | 99.76 |
| A69 | 1.00 | 3.00 | 12.09 | 51.15 | 622 | 1.68 | 11.76 | 0.63 | 117 | 137 | 992 | 6.48 | 29 | 80 | 181 | 111 | 49 | 787 | 20 | 109 | 269 | 20 | 42 | 20 | 80 | 6 | 11.34 | 99.49 |

variation is comparably high ($vt = 1.95$) and reflects polygenic population (Buxeda i Garrigós and Kilikoglou 2003). The evenness chemical variability graph showed that Pb introduces a major part of the chemical variability, due to high concentrations measured in a few samples, which appears to be a result of contamination. For this reason, it was excluded from the dataset. Apart from Pb, the elements excluded from the dataset were Cu, Na, P and Ba, not least since their variability may be related to the original use or post-depositional conditions (e.g. Picon 1991; Buxeda i Garrigós 1999; Schwedt et al. 2004). After removing these elements, the total variation is lower ($vt = 0.84$) and it may represent monogenic population. Furthermore, the results of testing of the similarity or dissimilarity of all samples towards the groups' average compositions allowed for establishing final chemical cluster comprising 51 samples and two loners (A.52 and A.53). It is important to note, however, that the samples gathered together do not form a very tight compositional group, but rather constitute a loose cluster, which is characterised by a relatively high total variation: $vt = 1.80$ for all elements and $vt = 0.75$ without Pb, Cu, P, Na and Ba, and fairly high relative standard deviations for the most elements (Table 6).

Fifteen samples, representative of the macroscopic and chemical variability of the assemblage, were selected for thin section petrography. All samples were classified to a single petrographic group because of overall similarity in mineralogy. However, two subgroups were defined on the basis of grain size distribution and frequency of inclusions. The thin sections classified into subgroup PG 1A (A.03, A.07, A.12, A.21, A.24, A.38, A.63, A.66 and A.69) are characterised by semi-coarse fabric, while samples of subgroup PG 1B are finer (A.14, A.18, A.42, A.44, A.46 and A.64). It is important to mention that dividing the samples into subgroups was difficult, because of the continuum seen in the frequency of inclusions, sorting and grain size distribution.

The overall fabric group is characterised by a calcareous clay matrix and inclusions of ophiolitic rocks, mudstone, carbonates and low and high calcareous Tcfs (Fig. 4). Fragments of serpentinite, various volcanic and plutonic rocks, as well as their constituent minerals, such as plagioclase feldspar, hornblende, pyroxenes, epidote group minerals, opaque minerals, chlorite and mica, form a suite of inclusions typical of ophiolitic rocks. Moreover, quartz, chert, limestone and calcite were identified. Carbonates include microfossils (foraminifera, ostracods and radiolarians) and micritic pellets. In most cases, the colour of the matrix is associated with its optical activity. When the micromass is yellow, orange or orange brown in PPL and yellowish orange, yellowish brown or red brown in XP, it is optically active to moderate. When the micromass is brown or greenish brown in PPL and dark brown or dark greenish brown in XP, it appears optically inactive. Slip layers have been identified in few samples (thickness 10–16 μm). It seems that the slip was made of very fine, iron-rich clay.

**Table 6** Mean chemical composition (oxides are expressed in wt% and elements in ppm) and relative standard deviation (rsd) of MG 9, MG 10, MG 11, MG 12, the final fabric group, a group of sugar moulds and molasses jugs from Kouklia (Waksman 2014; Tables 2 and 4), as well as chemical composition of the briquettes made of the geological samples and fired at 700 °C and 900 °C

| | MG 9, *n* = 18 | | MG 10, *n* = 10 | | MG 11, *n* = 17 | | MG 12, *n* = 8 | | Final fabric group, *n* = 51 | | Sugar moulds and molasses jugs, *n* = 5 (Waksman 2014) | | Geological samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | Ezousa river | | Armou | | Agriokalami stream | | Paphos, Ancient Agora | |
| | | | | | | | | | | | | | Temperature in °C | | | | | | | |
| | Mean | rsd | Mean | rsd | Mean | rsd | Mean | rsd | Mean | rsd | Mean | rsd | 700 | 900 | 700 | 900 | 700 | 900 | 700 | 900 |
| $Na_2O$ | 0.89 | 33 | 0.89 | 16 | 0.98 | 33 | 1.20 | 29 | 0.94 | 30 | 1.21 | 27 | 0.97 | 0.88 | 0.60 | 0.62 | 0.50 | 0.48 | 0.45 | 0.44 |
| MgO | 3.38 | 17 | 3.33 | 15 | 3.51 | 14 | 3.84 | 21 | 3.44 | 16 | 3.69 | 10 | 3.45 | 3.60 | 2.33 | 2.35 | 3.65 | 3.64 | 1.92 | 1.95 |
| $Al_2O_3$ | 13.00 | 13 | 12.58 | 10 | 13.24 | 9 | 11.70 | 11 | 12.84 | 11 | 15.07 | 10 | 10.45 | 10.94 | 11.79 | 12.00 | 6.53 | 6.85 | 16.76 | 17.03 |
| $SiO_2$ | 50.74 | 12 | 50.88 | 5 | 52.31 | 8 | 44.97 | 12 | 50.69 | 10 | 55.78 | 4 | 52.80 | 55.93 | 72.05 | 73.61 | 39.67 | 43.91 | 58.21 | 58.60 |
| P | 997 | 58 | 975 | 27 | 985 | 23 | 856 | 16 | 974 | 39 | 651 | 19 | 669 | 701 | 975 | 1007 | 591 | 595 | 461 | 484 |
| $K_2O$ | 1.71 | 19 | 1.82 | 13 | 1.70 | 14 | 1.50 | 21 | 1.71 | 16 | 1.92 | 23 | 1.11 | 1.21 | 0.95 | 0.97 | 0.86 | 0.92 | 2.61 | 2.67 |
| CaO | 13.31 | 34 | 14.85 | 20 | 13.95 | 22 | 17.89 | 19 | 14.39 | 26 | 12.75 | 36 | 15.37 | 17.35 | 5.14 | 5.18 | 28.53 | 32.16 | 4.93 | 5.51 |
| $TiO_2$ | 0.68 | 16 | 0.68 | 10 | 0.71 | 13 | 0.68 | 25 | 0.68 | 15 | 0.72 | 10 | 0.52 | 0.55 | 0.50 | 0.52 | 0.34 | 0.36 | 0.95 | 0.97 |
| V | 132 | 21 | 117 | 18 | 131 | 17 | 114 | 12 | 125 | 18 | 183 | 16 | 120 | 127 | 93 | 93 | 80 | 80 | 143 | 142 |
| Cr | 110 | 19 | 112 | 13 | 126 | 18 | 143 | 26 | 120 | 21 | 149 | 20 | 281 | 244 | 75 | 80 | 1225 | 1232 | 304 | 354 |
| Mn | 1017 | 12 | 1083 | 23 | 1115 | 15 | 987 | 23 | 1064 | 17 | 890 | 16 | 1282 | 1459 | 461 | 470 | 1304 | 1573 | 2096 | 2120 |
| $Fe_2O_3$ | 6.78 | 17 | 6.42 | 10 | 6.89 | 13 | 6.75 | 17 | 6.70 | 13 | 8.39 | 12 | 6.13 | 6.21 | 3.78 | 3.85 | 3.92 | 4.06 | 8.73 | 8.87 |
| Co | 25 | 12 | 25 | 8 | 26 | 13 | 23 | 12 | 25 | 12 | nd | | 25 | 26 | 13 | 17 | 23 | 26 | 25 | 26 |
| Ni | 86 | 22 | 91 | 18 | 92 | 18 | 98 | 43 | 91 | 24 | 89 | 8 | 120 | 127 | 35 | 40 | 187 | 175 | 126 | 126 |
| Cu | 131 | 36 | 124 | 27 | 110 | 16 | 123 | 37 | 122 | 30 | nd | | 130 | 116 | 62 | 66 | 65 | 120 | 59 | 62 |
| Zn | 105 | 14 | 82 | 20 | 99 | 12 | 90 | 17 | 96 | 17 | 84 | 11 | 114 | 167 | 73 | 73 | 59 | 61 | 101 | 100 |
| Rb | 58 | 24 | 60 | 22 | 61 | 19 | 46 | 22 | 59 | 21 | 52 | 21 | 45 | 50 | 36 | 36 | 30 | 34 | 101 | 96 |
| Sr | 678 | 45 | 911 | 25 | 648 | 30 | 813 | 26 | 733 | 30 | 544 | 31 | 368 | 409 | 170 | 173 | 576 | 627 | 222 | 231 |
| Y | 23 | 9 | 24 | 7 | 24 | 10 | 21 | 8 | 23 | 10 | nd | | 21 | 20 | 35 | 37 | 18 | 19 | 56 | 56 |
| Zr | 112 | 24 | 114 | 10 | 110 | 13 | 95 | 16 | 111 | 17 | 107 | 8 | 97 | 99 | 94 | 94 | 77 | 78 | 256 | 255 |
| Ba | 492 | 48 | 668 | 51 | 524 | 34 | 344 | 36 | 528 | 45 | 393 | 58 | 217 | 235 | 48 | 84 | 229 | 218 | 365 | 349 |
| La | 25 | 25 | 27 | 23 | 26 | 31 | 17 | 50 | 25 | 29 | 22 | 26 | 14 | 21 | 14 | 22 | 17 | 25 | 54 | 46 |
| Ce | 47 | 24 | 52 | 20 | 48 | 23 | 33 | 26 | 47 | 23 | 51 | 18 | 37 | 42 | 47 | 36 | 42 | 42 | 103 | 103 |
| Nd | 24 | 25 | 24 | 24 | 23 | 26 | 16 | 36 | 23 | 28 | nd | | 21 | 20 | 28 | 25 | 20 | 11 | 46 | 49 |
| Pb | 50 | 67 | 171 | 70 | 43 | 61 | 85 | 162 | 78 | 116 | nd | | 39 | 35 | 16 | 25 | 17 | 17 | 28 | 29 |
| Th | 7 | 35 | 8 | 17 | 7 | 25 | 6 | 15 | 7 | 27 | nd | | 6 | 5 | 4 | 4 | 1 | 4 | 13 | 12 |

*nd* not determined

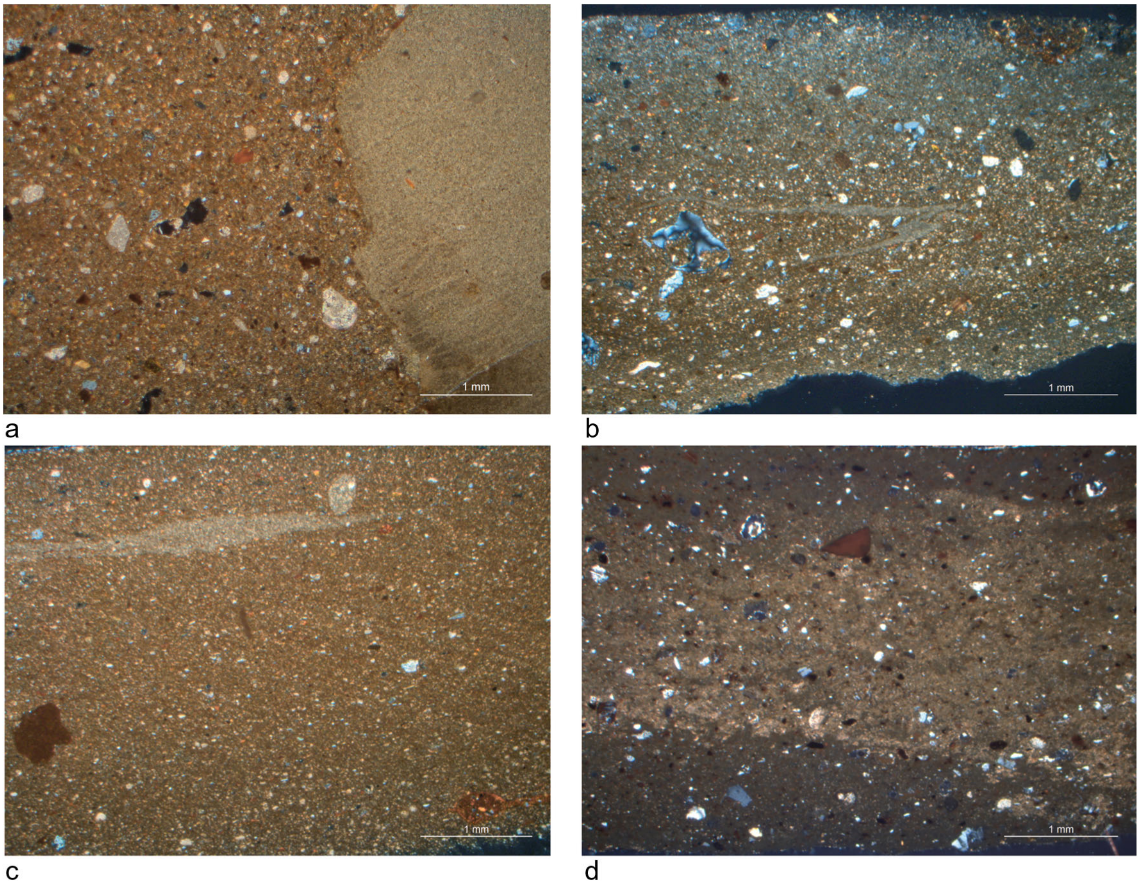


**Fig. 4** Thin section photomicrographs, in crossed polarised light (XPL). **a** Sample A.69 (MG 9). **b** Sample A.12 (MG 10). **c** Sample A.44 (MG 11). **d** Sample A.46 (MG 12)

The presence of various Tcfs types within the samples may suggest natural or intentional (anthropogenic) clay mixing (Fig. 4). The varied colours and optical activity both observed across all samples, as well as within single ones, indicate that the analysed vessels were fired under variable conditions and in a range of temperatures from low to high. Despite the differences within the group, the overall similarity of the mineralogy of inclusions indicates the use of raw materials associated with the same geological environment. The mineralogy of this fabric group is closely comparable to the geological sample collected from the Ezousa river, which is characterised by the presence of ophiolite components, such as intermediate to basic igneous rocks and serpentinite, as well as carbonates, microfossils, chert and mudstone. This similarity suggests that locally occurring raw materials were used for the production of the pottery assigned to this group.

In order to examine possible patterns within this group, chemical data were correlated to MGs, typology and the results of petrographic analysis (Fig. 5). Principal component analysis (PCA) was performed on the logratio transformed chemical data using $Al_2O_3$ as divisor since this element introduces the lowest variability. The analyses were carried out on the concentrations of the following 21 elements: Mg, Al, Si, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Zn, Rb, Sr, Y, Zr, La, Ce, Nd and Th. The results indicate that there is no correlation between the chemical composition of the samples and MGs (Table 6; Fig. 5a) nor typology (Fig. 5b). Instead, the origin of the variability within the cluster can be explained by both technological and taphonomic factors. The petrographic subgroups seem to show a pattern (Fig. 5c). Most of the samples classified to finer variant (PG 1B) tend to be distributed on the right side of the plot, suggesting that the high chemical variability may be related to the size and frequency of inclusions.

The observed variability of Cu and Pb may be related to the presence of metal objects in the deposit. It is worth noting that around 350 iron, bronze and lead objects were distributed from top to bottom of the well. Some samples (A.12, A.16, A.17, A.43, A.48, A.49, A.56 and A.67) show high Pb concentrations, reaching 424 ppm in sample A.67, and this appears to be directly linked to their local burial environment since all these vessels were found in contact with lead objects. Other elements which led to the high total variation of the 51 samples are Ca and Sr.

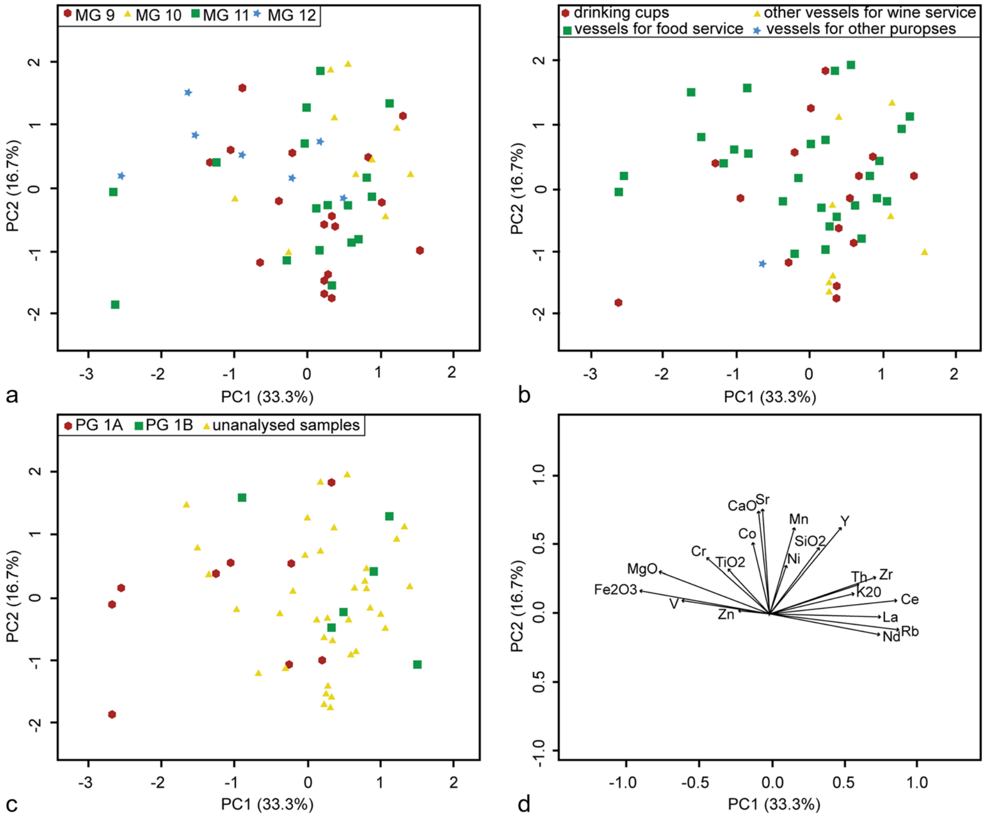


**Fig. 5** The principal component plot of the WD-XRF data including 21 elements for the 51 samples. **a** In correlation with the MGs. **b** In correlation with the typology. **c** In correlation with the petrographic subgroups (PG 1A and PG 1B). **d** Projections of discriminating elements

Variability in these may be related to post-depositional processes (leaching or deposition in pores) or to technological parameters. For the latter, it is crucial to note that potential evidence for clay mixing has been observed both in thin sections and under the SEM (where Ca-rich nodules were observed). The latter analysis also revealed the presence of unevenly distributed baryte inclusions. These are likely the origin of the relatively high variability in Ba observed. The mixing of different materials would have caused further perturbations in the samples' elemental compositions, in particular if recipes and or source materials themselves also show variation, likewise, if mixing of the materials had not resulted in complete homogenisation (Arnold et al. 1991), as is indicated by observations on thin sections and under the SEM.

Overall, the chemical composition of this group is comparable to Byzantine sugar moulds and molasses jugs from Kouklia (Waksman 2014), which also present high variability. This similarity suggests that this chemically heterogeneous group of pottery could have been produced in the region of Paphos. The chemical composition of one geological sample collected from an exposure by the Ezousa river further supports the assumption of local production (Table 6). Moreover, on the basis of chemical and mineralogical analysis, Roger H. King (1987: 207) already suggested that prehistoric and Iron Age pottery discovered in the area of Palaipaphos is similar in composition to clay from the upper Ezousa river.

Ten samples were examined under the SEM, revealing a range of microstructures, with some samples not showing any vitrification while others were extensively vitrified (Fig. 6). The degree of vitrification combined with the atmosphere of firing and high CaO content indicates that these pots were fired in a wide range of temperatures. Overall, the macroscopic grouping of the pottery into four MGs appears to relate mainly to differences in firing rather than to the composition of the clay paste (Table 7).

In all samples analysed, the slip layers appear to be very thin and do not exceed 16 μm in thickness. The slip layers are composed of a finer material than the ceramic bodies. No significant chemical variations were observed between the ceramic bodies and slip layers. The latter present a slight depletion of CaO and MgO with an enrichment of $K_2O$ in the surface layers.

The examination of the samples under the SEM led to the identification of high calcareous clay pellets (up to 42% of CaO) as well as a range of carbonate materials (e.g. secondary calcite infilling in voids and microfossils), features which were already seen in thin sections (Fig. 7). Their varied presence, as discussed above, may have contributed to the relatively high variability of CaO and Sr within this group.

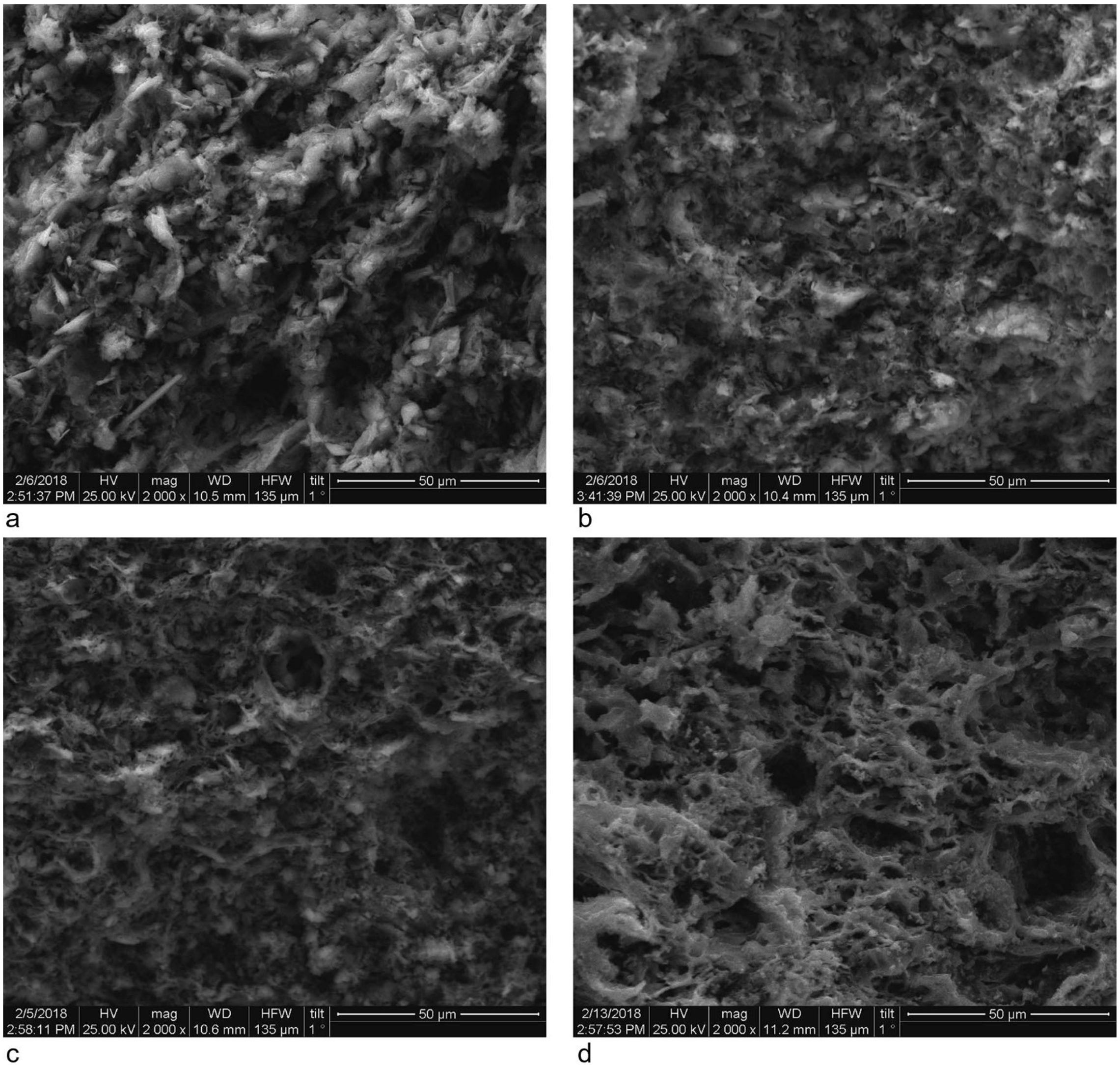


**Fig. 6** The SEM micrographs (in secondary electron mode) showing the range of the degree of vitrification of the ceramic body. **a** Sample A.18 (MG 9) showing initial vitrification. **b** Sample A.21 (MG 10) showing no vitrification to initial vitrification. **c** Sample A.44 (MG 11) showing initial vitrification to extensive vitrification. **d** Sample A.07 (MG 12) showing extensive vitrification

**Table 7** The results of SEM examination combined with the results of macroscopic, thin section and WD-XRF analyses

| Sample | MG | Shape | Slip colour | Firing atmosphere | Optical activity | CaO (wt%) | Vitrification of body |
|---|---|---|---|---|---|---|---|
| A.18 | 9 | Late with rolled rim | Red | O- | MD | 12.91 | IV |
| A.63 | 9 | Large plate with sloping rim | Red | O- | AC | 13.23 | NV–IV |
| A.69 | 9 | Echinus bowl | Red | O | AC | 11.76 | NV–IV |
| A.21 | 10 | Plate with rolled rim | Brown | M | AC | 12.90 | NV–IV |
| A.42 | 10 | Large echinus bowl | Brown | M | AC | 14.07 | NV–IV |
| A.24 | 11 | Lekane | Black | M | MD | 10.04 | IV–V |
| A.38 | 11 | Large plate with sloping rim | Red | O | MD | 15.01 | IV–V |
| A.44 | 11 | Jug with cylindrical neck and ovoid body | Red | O | MD | 18.75 | IV–V |
| A.07 | 12 | Lekane | Black/dark brown | M | IA | 14.67 | V |
| A.46 | 12 | Echinus bowl | Black/dark brown | M | IA | 13.56 | V |

Firing atmosphere (based on macroscopic analysis): O = oxidised, O- = not fully oxidised, M = mixed; optical activity (based on thin section petrography): AC = active, MD = moderate, IA = inactive. The CaO concentrations were assessed based on WD-XRF data. Vitrification: NV = no vitrification, IV = initial vitrification, V = extensive vitrification

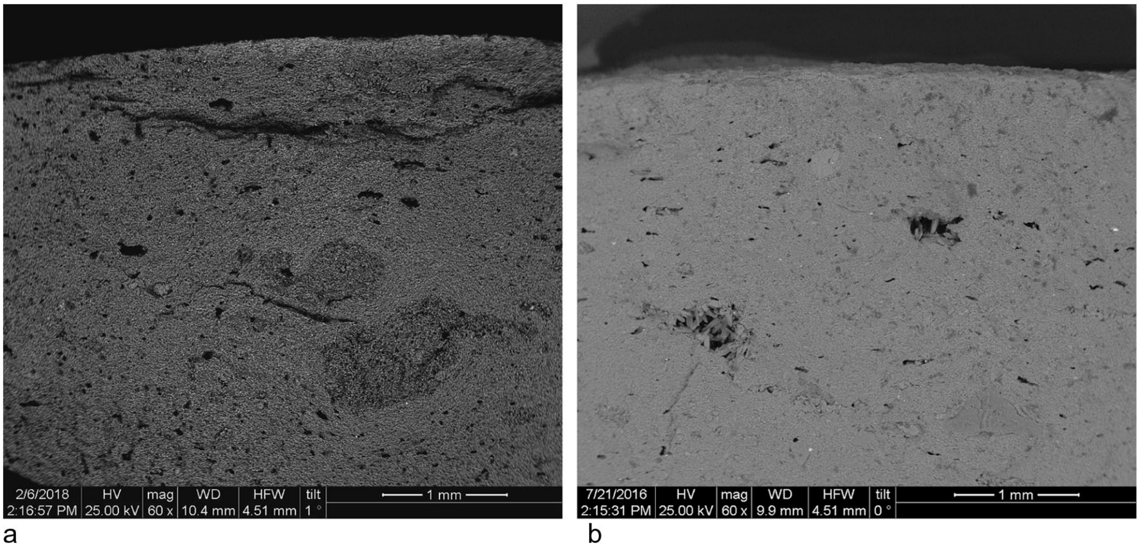


**Fig. 7** The SEM micrographs (in backscattering mode) showing **a** high calcareous clay pellets, sample A.18 and **b** secondary calcite infilling voids, sample A.63

## Summary and conclusions

The results of the integrated studies indicate that most of the analysed CCW vessels (51 out of 53) from the Late Hellenistic well deposit unearthed in the Paphos-Agora form one, albeit somewhat variable, fabric group, which was made from raw materials associated with the same geological unit(s), potentially from the same broader area. This fabric group includes samples, which at the outset of the research had been classified into four major typologically and stylistically related MGs, separated due to variation related to the inclusion frequency, colour, hardness, the feel of the surface and the texture of the fresh break. However, the results of chemical analysis indicated that they constitute a loose cluster, which does not exhibit any meaningful internal patterns in terms of either MGs or vessels types. This suggests that despite the observed variability, the MGs appear to be related to the similar provenance or raw material selection. This finding is supported by the petrographic analysis, which shows that all analysed samples are very similar and they belong to a single petrographic group, showing internal (continuous) variation of the frequency, sorting and grain size distribution of inclusions. This fabric group is characterised by the presence of ophiolite components and more specifically fragments of intermediate to basic igneous rocks and serpentinite, mudstone, carbonates, as well as Tcfs. The mineralogical and elemental composition of the vessels ascribed to this fabric group is similar to the composition of at least one clay sample that was collected from a section of the Ezousa river, which is around 5 km distant from the ancient town. Despite this similarity, it seems unlikely that this sample represents a source consistently exploited for such a large scale pottery production, but it suggests that the raw materials used for CCW are compatible with the geology of this area. Further indication for the local origin of this pottery is provided by the observation that its chemical composition is similar to the composition of the Byzantine sugar moulds and molasses jugs considered to have been produced in the vicinity of Nea Paphos (Waksman 2014). It seems that most of the analysed samples represent locally produced pottery. This is in accordance with the results of John Lund's (2015: 158–160) work on the circulation of pottery in Hellenistic and Roman Cyprus, which indicated that the majority of pottery was manufactured locally.

The macroscopic and compositional variability of this group may be related to natural diversity of raw materials and technological/anthropogenic factors, introduced by a number of potters/workshops in the same area and by technological choices made by the potters. Finally, it seems to also be partly related to post-depositional processes.

It is worth mentioning that Hellenistic pottery from Knidos shows similar variability (Schneider 2000; Kögler 2011). Patricia Kögler (2011: 167; 2014: 168) argued that the production of low-quality fine ware pottery in Knidos in the Late Hellenistic period was linked to increasing demand, which she identified through the manufacture of wider range of types and an increase in quantity, as well as through a wider distribution than in the Early Hellenistic period. She suggested that the decrease in quality during the Late Hellenistic period was because workshops manufactured more vessels in the same amount of time than before and spent less time at each stage of production. Changes of a similar nature were also observed in other production centres in the Eastern Mediterranean. Susan Rotroff (1997: 11–12), for example, noted a decline in the potter's art at Athens in the Late Hellenistic period (for more examples Lund 2015: 219–220).

Assuming that the group of pottery presented here was indeed locally produced, similar explanation can be proposed for Nea Paphos. The importance of the city increased during the Late Hellenistic period, when it became the capital of the island at the end of the third or in the early second c. BCE (Lund 2015: 238). The development of Nea Paphos and its hinterland may have created increased demand for goods, including table ware pottery, which was easily broken and would have needed to be replaced quite often. Higher demand would have likely led to increased production, which one might speculate to have resulted in decreased quality and lower technological standardisation of the local production. These could be related with high-speed production (Hruby 2014) or increase in the numbers of workshops with less skilled potters (Albero Santacreu 2014: 257). Both assumptions are supported by low fabric standardisation and by signs of careless forming and surface treatment, often resulting in the production of non-symmetrical vessels, with some 'defects', such as deformed rim or base, and vessels covered only partially with a thin slip. Moreover, the relative lack of technological standardisation is also reflected in the observed variability in firing conditions. Variability in colour and optical activity of the matrix observed in thin sections, as well as the degree of vitrification, from no vitrification to extensive, assessed through SEM analysis, indicate that these pots were fired in a wide range of temperatures in not consistently controlled atmosphere. As this pottery comes from the same homogenous deposit at the Agora, its low quality and lack of technological standardisation could have been related with a specific context of pottery consumption, such as a feast, an event or series of events that would have encouraged production of such scale (Albero Santacreu 2014: 272). However, one can see similar variability in CCW of the same fabric group from other contexts in Paphos (Marzec 2017). A 'marked decline in quality and finish' in CCW of the first c. BCE was also observed by John Hayes (1991: 27) within the material from the House of Dionysos in Nea Paphos. Moreover, the preliminary results of ongoing studies focused on cooking pottery from this site show similar production pattern. It seems that this is the phenomenon of mass produced pottery characterised by low quality and low technological standardisation, increasingly observed in the Eastern Mediterranean during the Late Hellenistic period.

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