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ORIGINAL ARTICLE

Archaeometric investigations of the Late Roman Period red slip ware from Caesarea Germanicia (Kahramanmaraş, Southeastern Anatolia)

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Abstract

In the present study, red slip wares excavated from the ancient city of Germanicia (modern Kahramanmaraş, Southeastern Anatolia) were subjected to an archaeometric analysis. A multi-analytical approach was employed, including stereomicroscopy, optical microscopy, XRPD, SEM-EDS, and XRF to explore the mineralogical and chemical compositions of the samples. Based on both archaeological and archaeometric criteria, the samples were classified into three main categories: African, Phocaean, and Sagalassos red slip wares. The African red slip wares were characterized by an abundance of coarse quartz inclusion, accompanied by lesser quantities of plagioclase and mica. The Phocaean red slip wares primarily consisted of quartz, feldspar, and mica. In contrast, the Sagalassos red slip wares featured a groundmass rich in quartz, mica/biotite, hematite, and opaque minerals. Thermoanalytical data indicated that all samples were fired at temperatures between 800 and 900°C. The results suggest that red slip wares found at Germanicia were not manufactured using local available clay sources but rather originated from different regions. This evidence further provides that Germanicia was actively involved in trade networks and interacted with various ancient urban centers, such as Africa, Phocaean, and Sagalassos, during the Late Roman Period, between the fourth and fifth centuries AD.

KEYWORDS

African, archaeometry, Caesarea Germanicia, Kahramanmaraş, Phocaean, red slip ware, Sagalassos

INTRODUCTION

The Anatolian region has been the home of numerous significant ancient urban centers dating back to antiquity (Figure 1a,b). Over the millennia, these ancient settlements have undergone sustained historical transformations and cultural shifts in Anatolia. Material culture, including ceramic vessels such as bowls and plates, glass unguentaria, and amphorae, is an important part of urban life in these ancient contexts. The distribution of these artifacts across both proximate and distant settlements attests to the extensive trade networks that were operational during the Roman period.

Following the Mithridatic Wars (88–63 BCE), Anatolia fell under Roman rule entirely (Sartre, 2005). Roman expansion in the region was carried out in different ways and was shaped depending on the political conditions of the region and the period. During the Roman Empire, there was a comprehensive road system that served political and military purposes during wartime and commercial, religious, or cultural purposes during times of peace. In this historical context, the Anatolian cities of Kahramanmaraş and Germanicia remained strategically important, especially as key points in the trade and military networks that passed through the Kingdom of Commagene. Under Roman rule, Germanicia became a hub for six major roads, two of which were important military routes that connected to the Euphrates River and key cities like Edessa, Samosata, Doliche, and Zeugma. These military routes were strategically designed to connect Germanicia (Kahramanmaraş) to the Syrian frontier (Anderson, 1897; Ramsay, 1890; Ramsay & Hogarth, 1893).

Archaeological data regarding the Roman period, obtained from excavations in Germanicia, are extremely limited. This makes it difficult to date the Roman strata. Apart from some architectural remains, such as walls and mosaic floor coverings from the Late Roman Period in the excavated areas, terracotta ceramics provide important data. The red slip ware analyzed in this study provides initial insights into the commercial and economic landscape of Germanicia during the Late Roman Period (fourth to fifth centuries AD). The primary focus of this data set encompasses so-called Sagalassos, Africa, and Phocaean red slip wares. Sagalassos red slip ware (SRSW) have a broad distribution across Anatolia and have been discovered in ancient settlements spanning the regions of Pisidia, Cilicia, Pamphylia, Lykia, Ionia, Lydia, and Phrygia (Ok, 2018b; Poblome, 1999). In addition to Anatolia, this type of ceramic has been identified in various settlements along the Mediterranean coast, extending to countries with Mediterranean shorelines, including Italy, Tunisia, Libya, Egypt, Syria, and Israel (Willet & Poblome, 2015). Phocaean red slip ware (PRSW) have been found in various Anatolian cities, for example, in the Ionia Region, as well as in Troas, Phrygia, Cilicia, Caria, Lykia, and Lydia (Hayes, 1980; Ok, 2018a). Beyond Anatolia, these ceramics have also been found in other regions such as Caesarea in Israel (Magness, 1995), Lower Egypt, Syria, Palestine, Sicily, and Russia (Hayes, 1972, 2008). In addition to the red slip wares from Sagalassos and Phocaean, which had their production centers within Anatolian, Germanicia was actively engaged in overseas trade. In this context, African red slip ware (ARSW) serve as significant indicators of this trade activity. These ceramics, mainly produced in North African, especially in Tunisia (Neuru, 1987), were utilized in various Mediterranean settlements (Hayes, 1980). ARSW were widely used in many settlements in Anatolia (Ok, 2018a). Ceramics originating from different production centers in Germanicia were categorized into distinct groups based on their paste and slip characteristics. These ware groups are important as they show that the people of Germanicia were not indifferent to the use and trade of red slip wares produced in Sagalassos, Phocaean, and Africa.

This study aims to characterize the mineralogical, petrographic, and geochemical characteristics of red slip ware from Germanicia, as identified through archaeological data. The study also examines various production techniques, such as firing temperatures and their variations within the samples from other red slip ware groups. Understanding the production place of these wares is crucial for determining whether they represent imported ceramics or the introduction of a foreign ceramic tradition into Germanicia. Additionally, the analytical findings offer insights into the types of ceramics used in Germanicia during the Roman Empire. As the selected red slip wares are not directly linked to local production, their analytical data are discussed separately.

ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

In Kahramanmaraş (formerly Maraş), where evidence of continuous habitation dates back to the third millennium BCE, a succession of kingdoms or city-states—including Mama, Gurgum, Antiochia ad Taurum, and Caesarea Germanicia (Billerberck, 2006; Magie, 1950; Millar, 1993; Zoroğlu, 2005)—was established (Dumankaya, 2019). In illicit excavations conducted in the Dulkadiroğlu district in the early 2000s, remnants of Roman Period buildings were uncovered. Subsequent archaeological investigations led by the authors have revealed that these remnants are dispersed across an area of approximately 150 ha (Dumankaya, 2017) (Figure 1a,c). Given the extensive spatial distribution of these building remnants, it is posited that they likely belong to Germanicia, a significant urban center of the Roman Period. Although the region is rich in cultural heritage, the Dulkadiroğlu district is densely populated with modern structures, thereby impeding further archaeological excavations for scientific data

FIGURE 1 (a) Location map of the Caesarea Germanicia (?). (b) Trade roads of Ancient Roman Period *c*. Caesarea Germanicia (?) 3rd Degree Archaeological Site Boundary. (d) A view from the Roman Bath or Villa Rustica (?)

collection. Despite these challenges, archaeological excavations were initiated in 2001, 2009, 2010, and 2016 in various cadastral blocks within the Dulkadiroğlu district (Dumankaya, 2018b).

Founded in 38 AD in honor of the empire by Commagene King IV Antiochus, the city is historically referred to as Kaisereia Germanikeia (Lat. Caesarea Germanicia) (Magie, 1950; Millar, 1993; Zoroğlu, 2005). The earliest information about the city is reported in the work 'Geography' (Geographica V.15.10) by the second-century AD geographer Ptolemy. Additional data are available in Gaius Asinius Quadratus' 'Parthika' (Millar, 1993), Stephanus Byzantinus' 'Ethnica' (Billerberck, 2006), and Theodoret, the Bishop of Cyrrhus/Kyrrhos, in his 'Historia Ecclesiastica' (Clayton, 2007) (AD *c*. 393–*c*. 466). Another source mentioning the city's name is an inscription (*c*. 260) commissioned by Sassanid Shah I Shapur (Reign: AD 240–270) in Ka'ba-ye Zartosht (Wiesehöfer, 2018). In this trilingual inscription, rendered in Greek, Pahlavi (Middle Persian/Pārs⊠g), and Persian (Rapp, 2014), the city is referred to as Germanikia/Γερμανίκια in Greek, Glmnwsy (Garmanos/Germaniyos) in Peh., and Grmnyws (Germanyōs/Garmaniyōs) in Persian (Huyse, 1999, I.32; II.124–125). Between 161 and 249 AD, coins were minted in the city during the reigns of Marcus Aurelius, Lucius Verus, Commodus, Macrinus, and Philippus. The inscriptions on the earliest coins read 'KAICARI/GIRMAN/IKI KOM/A' (καιςαρ (εῶν) Γερμανικῶν), signifying the name of Kaisareia and Germanike Kaisareia (Redgate, 1998; Tekin, 2010; Urban, 1835). The issuance of coins under these emperor's underscores Germanicia's status as a significant city within the Roman Empire. Despite its importance, no definitive source providing detailed information about its localization has been identified. Consequently, assessments regarding the city location are based on data from research and excavations (Dumankaya, 2017, 2018a, 2018b, 2018c). Therefore, it is crucial to conduct comprehensive studies on all findings obtained from research and excavations.

Germanicia (?) excavations (2019 and 2020)

Prior to the 2019 excavation season in the Dulkadiroğlu district, numerous Roman structures featuring mosaic floors were unearthed. These mosaics contained various panels depicting rural life, natural landscapes, human figures, animals, architectural elements, geometric patterns, mythological scenes, and botanical motifs. The diverse subject matter of these panels provides valuable insights into the social structure, fauna, flora, and architectural styles of Caesarea Germanicia. During the two-year archaeological excavation period spanning 2019–2020, a Roman bath (?) was discovered, which had damaged due to illicit excavations. Signs of this destruction are evident at the foundation level on the walls, the hypocaust system, and the mosaic flooring (Figure 1d). Additionally, it was observed that repairs had been made to the building's walls, suggesting secondary utilization over subsequent centuries. These repairs indicate that the structure has been repurposed over time. The mosaic flooring suggests that the building in question is contemporaneous with other structures, with remnants dating back to the fourth to sixth centuries AD. Despite the challenges posed by illegal excavations and soil deposition, artifacts representing earlier phases were also identified. This study will focus on evaluating the archaeological remains that shed light on the commercial relationships of the settlement.

MATERIALS AND METHODS

Red slip ware samples

The ware group, dated to the fourth to sixth centuries century AD, was unearthed in a bath structure during the 2019–2020 excavations (Figure 1d). A total of 22 samples were selected to examine petrographic, mineralogical, and chemical characteristics and to differentiate according to their macroscopic properties (color, shape, etc.). Archaeological classification of wares was done using macroscopic observations to assess groundmass, slip, and form typologies. The composition of minerals, groundmass color, and slip features provided preliminary classification criteria. Based on archaeological analysis, they were classified into three groups: ARSW, PRSW, and SRSW (Table 1).

ARSW are typically bowl shaped; their paste is dense with small voids (low porosity) and mainly contains carbonate inclusions. The surface color closely resembles that of the paste. ARSW are characterized by their red interior and exterior hues; the surface is semimatte, featuring fine pores created by carbonate flakes. Although the majority of wares belong to the Hayes Form 67 category, one specimen from the Hayes Form 61A group has been identified in Germanicia.

PRSW are also predominantly bowl shaped. The paste is dense, with a fine texture, and includes mica and lime inclusions. PRSW are distinguished by their yellowish-red color, which is consistent with the color of the paste. Two forms belonging to this group, Hayes Form 3C and Form 3E, were found in Germanicia.

SRSW are available in both bowl and plate forms; their paste is dense, with fine pores, and contains carbonate fragments. There is a small variation in the color and texture of the SRSW samples. The groundmass is dense, and all samples are fine grained. The groundmass colors generally show a yellowish-red hue, although some samples (S2, S7) display brownish hues. The slips have a polished surface and range in color from yellowish red to red (Table 1). Within the scope of this study, SRSW were classified into five different forms: 1B100, 1B101, 1B130, 1B230, and 1C100 (Poblome, 1999).

Methods

First, we defined the paste color of selected samples using a PCE-CSM1 Colorimeter at the Department of Geological Engineering of Pamukkale University and converted it to 'Munsell Soil-Colour Charts 2010' standards. Overall macroscopic features of wares were examined with a Leica EZ4 W stereomicroscope. For petrographic analysis, thin sections from each sample were prepared and analyzed using a standard polarization microscope (Leica DM750P) at the same department. The chemical composition, including major and trace elements, was determined using a Spectro XLAB 2000 PEDXRF X-ray spectrometer at the Advanced Technology Application and Research Center (ILTAM) of Pamukkale University. A portion of each sample was first ground to approximately 200 mesh, then formed into 32-mm discs with a special XRF binder, and subsequently analyzed. In addition, X-ray powder diffraction (XRPD) analyses of eight samples were conducted at the ILTAM of Pamukkale University. The XRPD method is used to determine mineral phases in the samples, particularly the fine-grained clay matrix that is too small for microscopic examination. Initially, the samples were grinded into powder using a ring grinder, and nonoriented plaques were prepared for analysis. XRPD measurements were taken using a GNR APD 2000 PRO diffractometer under specific conditions (CuKα, 40 kV, 30 mA; 2θ: 5–45°; step intervals: 0.01; integration time: 2 s). Scanning electron microscopy and energy-dispersive spectroscopy (SEM-EDS) analyses of six samples were performed to characterize crystal morphologies. This SEM-EDS work was carried out at the

TABLE 1 Identification of the interior and surface colors and forms of the all samples.

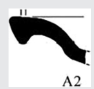
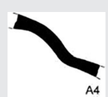
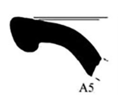
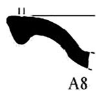
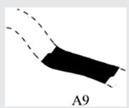
Sample number	The red slip ware forms	Sample photograph	Form of the red slip ware	L	a	b	Muncell	Color	Color
A1			Form 61A	52.15	22.41	25.34	2.5YR 5/8	Red	Inner
				53.64	25.40	23.80	2.5YR 5/8	Red	Surface
A2			Form 67	52.67	24.06	25.28	2.5YR 5/8	Red	Inner
				55.13	21.68	23.24	2.5YR 5/6	Red	Surface
A3			Form 67	55.29	23.04	26.29	2.5YR 5/8	Red	Inner
				48.74	25.48	28.17	2.5YR 5/8	Red	Surface
A4			Form 67	51.21	22.45	23.08	2.5YR 5/6	Red	Inner
				54.79	22.46	23.94	2.5YR 5/6	Red	Surface
A5			Form 67	51.67	23.45	24.20	2.5YR 5/6	Red	Inner
				54.13	20.68	23.66	2.5YR 5/6	Red	Surface

TABLE 1 (Continued)

Sample number	The red slip ware forms	Sample photograph	Form of the red slip ware	L	a	b	Muncell	Color	Color
A6			Form 3C/E	54.56	20.83	26.19	5YR 5/6	Yellowish red	Inner
				52.09	24.75	28.38	5YR 5/8	Yellowish red	Surface
A8			Form 67	52.39	22.96	24.43	2.5YR 5/6	Red	Inner
				54.32	24.54	25.63	2.5YR 5/6	Red	Surface
A9			Form 67	56.50	21.11	25.31	2.5YR 5/6	Yellowish red	Inner
				50.35	22.18	24.23	2.5YR 5/8	Red	Surface
A10			Form 67	54.39	21.46	26.25	2.5YR 5/8	Yellowish red	Inner
				51.77	25.20	27.05	2.5YR 5/8	Red	Surface
F1			Form 3C	49.72	19.57	23.48	5YR 5/6	Yellowish red	Inner
				52.45	18.77	24.24	5YR 5/6	Yellowish red	Surface

(Continues)

TABLE 1 (Continued)

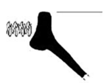
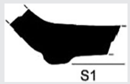
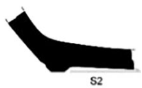
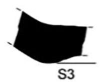
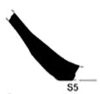
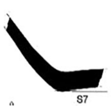
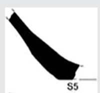
Sample number	The red slip ware forms	Sample photograph	Form of the red slip ware	L	a	b	Muncell	Color	Color
F2			Form 3E	54.57	23.00	31.41	5YR 5/8	Yellowish red	Inner
				55.36	22.08	28.82	5YR 5/8	Yellowish red	Surface
F3			Form 3C	54.51	19.52	23.55	5YR 5/6	Yellowish red	Inner
				55.47	18.52	28.83	5YR 5/6	Yellowish red	Surface
F4			Form 3C	56.03	22.90	30.65	5YR 5/8	Yellowish red	Inner
				52.08	22.42	28.54	5YR 5/8	Yellowish red	Surface
F5			Form 3E	54.51	18.03	23.18	5YR 5/6	Yellowish red	Inner
				55.52	18.32	28.41	5YR 5/6	Yellowish red	Surface
F6			Form 1B 100	52.23	21.00	28.02	2.5YR 5/6	Red	Inner
				51.23	22.44	30.56	2.5YR 5/6	Red	Surface

TABLE 1 (Continued)

Sample number	The red slip ware forms	Sample photograph	Form of the red slip ware	L	a	b	Muncell	Color	Color
S1			Form 1B 230	47.60	20.14	23.30	5YR 5/6	Yellowish red	Inner
				50.89	23.60	28.59	5YR 5/8	Yellowish red	Surface
S2	     		Form 1B 230	47.73	5.40	10.10	7.5YR 5/2	Brown	Inner
				42.32	14.93	18.32	5YR 4/4	Reddish brown	Surface

(Continues)

TABLE 1 (Continued)

Sample number	The red slip ware forms	Sample photograph	Form of the red slip ware	L	a	b	Muncell	Color	Color
S3			Form 1B 130	51.00	16.67	23.24	5YR 5/6	Yellowish red	Inner
				51.92	17.32	22.46	5YR 5/6	Yellowish red	Surface
S4			Form 1B 230	49.09	20.78	26.72	5YR 5/6	Yellowish red	Inner
				49.12	24.00	27.19	5YR 5/8	Yellowish red	Surface
S5			Form 1C 100	49.41	21.61	27.35	5YR 5/8	Yellowish red	Inner
				53.34	23.00	25.03	2.5YR 5/8	Red	Surface
S6			Form 1B 101	48.24	20.41	29.21	5YR 5/8	Yellowish red	Inner
				47.19	24.61	25.14	2.5YR 5/8	Red	Surface
S7			Form 1C 100	51.07	11.25	21.67	7.5YR 5/4	Brown	Inner
				48.43	12.24	14.43	5YR 5/4	Reddish brown	Surface

ILTAM of Pamukkale University using an FESEM SUPRA 40 VP. Samples for SEM-EDS analysis were prepared by adhering a freshly broken surface to an aluminum stub using double-sided tape and then coating it with an Au/Pd film using a Quorum Sputter Coater.

RESULTS

Stereomicroscope and thin section analysis

To evaluate the selected samples, which are categorized into three distinct groups based on their archaeological features, both macroscopic and microscopic mineralogical analyses were conducted. Stereomicroscopic examination revealed clear differences among the sample groups. ARSW samples contain predominant quartz minerals in the groundmass, approximately 0.6 mm in size (Figure 2a). In contrast, PRSW samples show less and smaller quartz minerals, around 0.1 mm in size (Figure 2b). Coarse minerals were not clearly visible, which instead showed small-sized quartz and secondary calcite grains, in SRSW samples (Figure 2c). Sample F1 was unique, containing a significant amount of rock fragments and quartz minerals approximately 0.5 mm in size (Figure 2d). This sample appears to differ from the archaeologically defined groups.

All samples displayed similar mineralogical compositions and were divided into three main groups based on the abundance of specific minerals. The first group, ARSW, is characterized by abundant and coarse quartz crystals (Figure 2e). It contains lesser amounts of plagioclase, mica (muscovite), and iron oxides. Mineral orientations were observed, although not evident in mica minerals. Although the general dimensions of quartz minerals are 0.1 mm, they are also observed in about 0.36 mm. Quartz minerals generally appear as angular grains and are monocrystalline. Plagioclase minerals were observed in limited quantities, measuring around 0.15 mm in size. Void formations, generally vesicle shaped, were approximately 0.85 mm in size. In some samples (A9), secondary calcite fillings were observed in these voids. Due to small mineral sizes, two samples (A2 and A8) were clustered as subgroups. A significant reduction in quartz dimensions is observed in these samples.

The second group, PRSW, contains quartz, secondary calcite, and lesser amounts of mica and amphibole minerals. Quartz minerals are less abundant than in ARSW and measure around 0.1 mm, with a maximum size of 0.3 mm. Amphibole minerals were observed in some samples (Figure 2f). Small biotite grains were prominently observed, with lesser amounts of muscovite. A distinct orientation was observed in the groundmass, and voids in the samples were filled with secondary calcite, distinct orientation in the groundmass. It is observed that the voids in the sample were filled with secondary calcite.

The third group, SRSW, is characterized by predominantly fine silicate crystals. These samples contain quartz, biotite, sparry calcites, opaque minerals, and very few pyroxene minerals. Quartz grains are generally monocrystalline and partially polycrystalline, with sizes ranging from 0.05 to 0.1 mm. Pyroxene minerals are uncommon and were notably observed in the S3 sample (Figure 2g). Unlike all other samples, sample F1 contained significantly more metamorphic rock fragments, approximately 1.5 mm in size. In addition to rock fragments, abundant quartz and opaque minerals were also observed. Irregularly shaped voids were observed in this sample (Figure 2h).

Correlations between matrix birefringence and biotite pleochroism in highly oxidized samples suggest firing temperatures between 800 and 850°C (Allepuz, 2021). The presence of cleavage in some biotite minerals, notably in samples S2 and S6, indicates firing temperatures greater than 950°C (Allepuz, 2021). However, this is not supported by the limited observations in SRSW samples, which generally showed weak or no pleochroism, suggesting that the firing temperatures likely did not reach those levels.

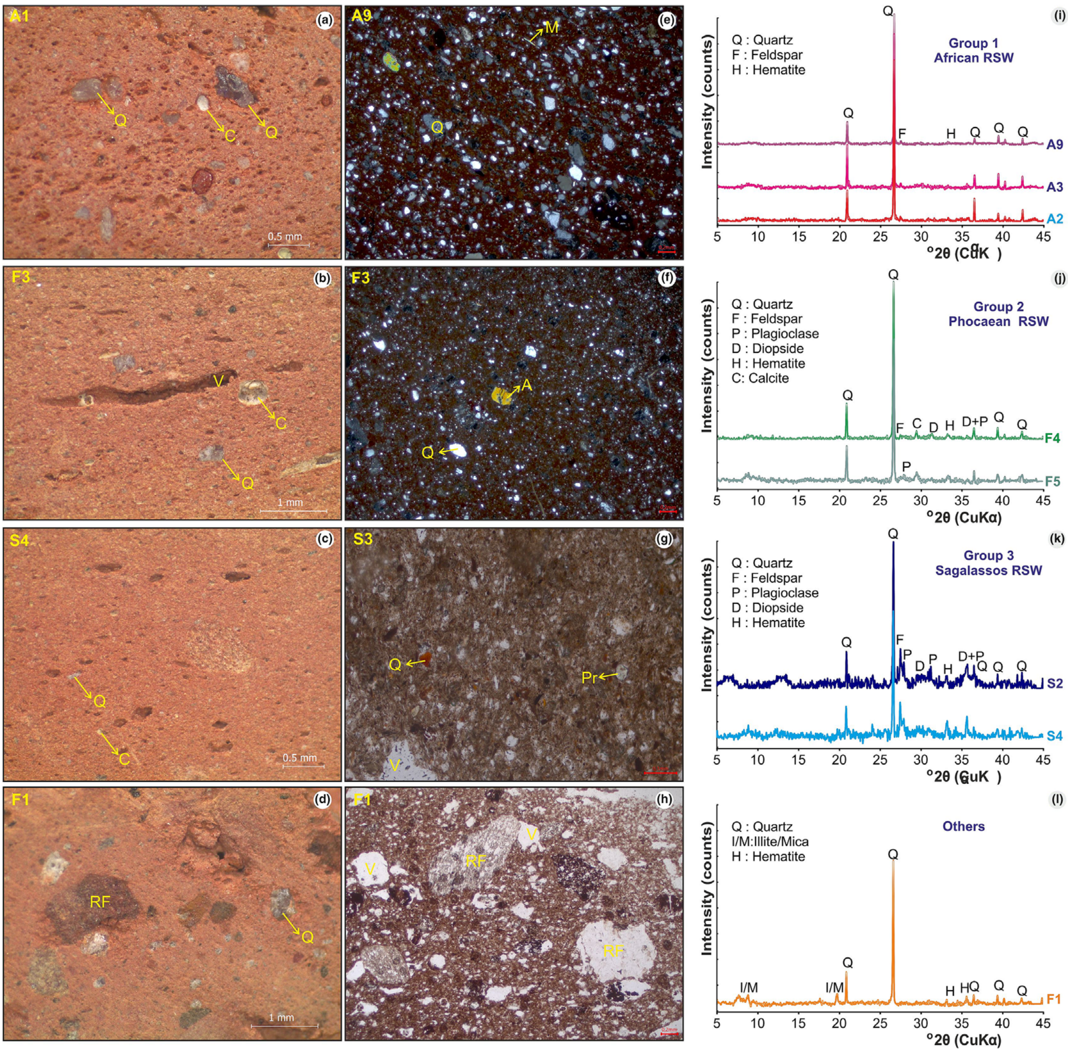


FIGURE 2 Stereomicroscope views of the (a) A1 sample (ARSW), (b) F3 sample (PRSW), (c) S4 sample (SRSW), (d) F1 sample. Optical microscope views of the (e) A9 sample (ARSW), (f) F3 sample (PRSW), (g) S3 sample (SRSW), (h) F1 sample. X-ray diffraction patterns of (i) ARSW, (j) PRSW, (k) SRSW, and (m) F1 sample taken from Germanicia ancient city. Bi, biotite; C, calcite; P, plagioclase; Pr, pyroxene; Q, quartz; RF, rock fragment; V, void.

XRPD analysis

To determine the mineralogical composition of the samples, XRPD analyses of selected samples were conducted. Table S1 provides a summary of the mineral assemblages identified in these samples. The results of XRPD analysis also show differences between the sample groups. In ARSW, quartz was identified as the dominant mineral, accompanied by lesser amounts of K-feldspar and hematite (Figure 2i). According to quantitative calculations, the average quartz content was 87.8%, the K-feldspar content ranged between 10.17%, and the hematite content was around 2.06% (see Table S1). In PRSW, quartz, plagioclase, K-feldspar, diopside, hematite, and calcite minerals were detected (Figure 2j). These samples were clearly distinguishable from ARSW due to a lower quartz content and higher feldspar minerals. The presence of calcite is considered to be secondary, as confirmed by stereomicroscopic and optical microscopic examinations. In SRSW, quartz, K-feldspar, plagioclase, and, to a lesser extent, diopside and hematite were identified (Figure 2k). Quartz and feldspar were the dominant minerals in most samples. Quantitative calculations revealed that the quartz content ranged between 24% and 35%, K-feldspar between 20% and 21%, and plagioclase between 24% and 30% (see Table S1). The quartz minerals were identified as α-quartz, and the plagioclase as albite. No significant calcite peak was observed, but a diopside peak of 18%–19% was detected. Hematite was present in both types of samples, with concentrations varying between 3% and 6%. Examination of the F1 sample revealed an abundance of quartz and illite/mica minerals, along with a small amount of hematite (Figure 2m).

The maximum firing temperature can be estimated according to the presence or absence of specific minerals in the analyzed samples (Cultrone et al., 2001; Fabrizi et al., 2020; Maritan et al., 2006; Semiz, 2017). The most significant mineralogical change during firing is the disappearance of clay minerals. The peak density of the clay phase decreases gradually with increasing firing temperatures, reaching approximately 700–800°C. Thermal decomposition of calcite begins around 600°C and completes at 800–850°C, depending on the specific firing conditions (Cultrone et al., 2001; Maritan et al., 2006; Semiz, 2017). Above 800°C, free CaO reacts with free silica and aluminum, resulting from the degradation of clay minerals, to form gehlenite between 850 and 900°C or 1050°C (Ortega et al., 2010). Anorthite can also form at these temperatures (Bertolino et al., 2009). In both oxidizing and reducing atmospheres at 850°C, fassaite, gehlenite, anorthite, and wollastonite have started to crystallise (Rathossi & Pontikes, 2010). Calcium silicates (diopside) appear in the range of 850–900°C (Seetha & Velraj, 2016). The absence of significant clay minerals in the thin sections and XRPD analyses of the red slip wares from Germanicia suggests that the firing temperatures between 800 and 900°C. Given that feldspar minerals observed in ARSW were also detected in microscopic images, the firing temperatures are estimated to be around 800–850°C. The matrix remains anisotropic and exhibits fine muscovite, indicating a firing temperature of approximately 800°C for the samples. The presence of initial vitrification and high-temperature minerals (diopside and plagioclase) in small amounts suggests that the firing temperatures for PRSW and SRSW were around 850–900°C. The K-feldspar and plagioclase (albite) peaks observed are thought to be originated from sand-sized grains in the clay. These data are highly consistent with the SEM-EDS results.

SEM-EDS analyses

SEM-EDS analyses offer valuable insights into the internal morphology of archaeological wares, particularly concerning the degree of vitrification, including the glassy phase and pore structure, during and after the firing of ceramic (Maniatis & Tite, 1981). A comparative analysis of the chemical and structural property differences among the samples was conducted using SEM-EDS at multiple points across six samples. The stages of vitrification during the firing can be categorized as 'No Vitrification (NV), Initial Vitrification (IV), Extensive Vitrification (EV), and Continuous Vitrification (CV)' (Maniatis & Tite, 1981; Semiz, 2021).

SEM examination of the six samples revealed similar characteristics among them. The emergence of isolated smooth-surfaced areas is considered the initial stage of vitrification (Figure 3a,c,e). This phase, termed the Initial Vitrification (IV) stage, is a common feature in both calcareous and noncalcareous clays. It is reported to develop in an oxidizing atmosphere at firing temperatures ranging from 800 to 850°C (Maniatis & Tite, 1981). The firing atmosphere can also be estimated according to the paste color of ceramic—oxidizing for red or brown and reducing for gray or black (Maniatis & Tite, 1981). The observed colors—red, yellowish-red, and brown—support the notion of an oxidizing atmosphere, consistent with the

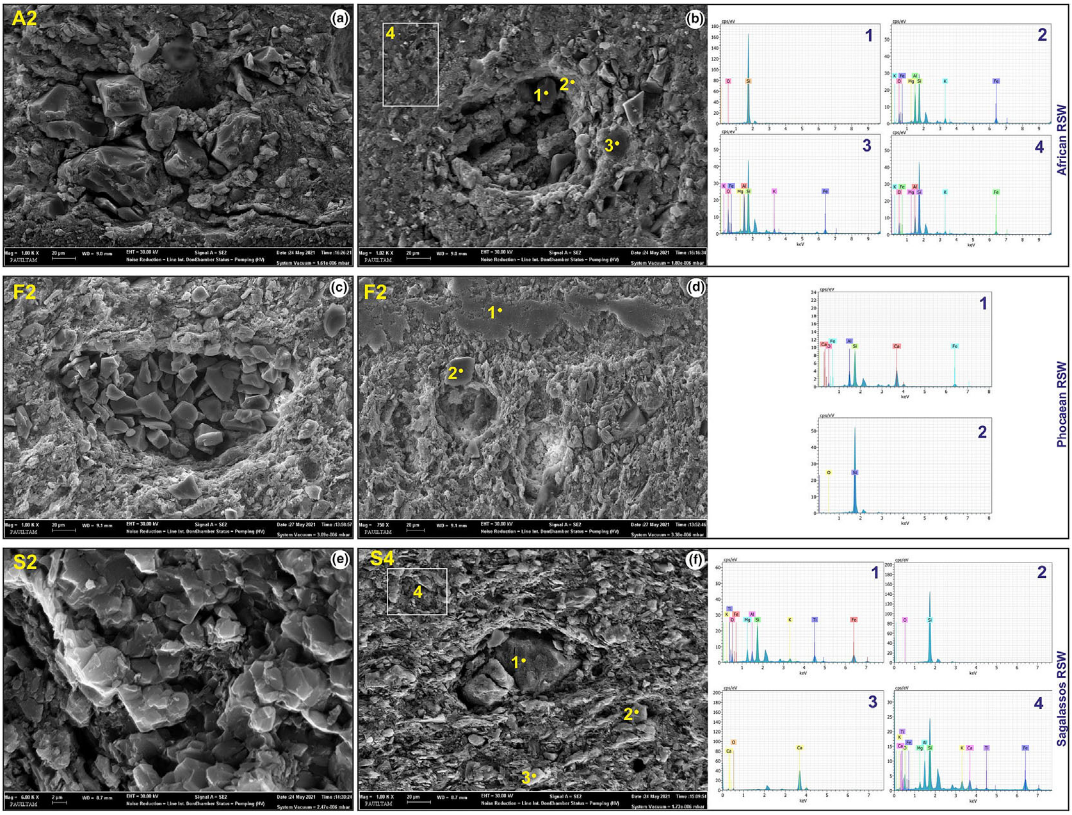


FIGURE 3 (a) SEM image with (b) EDS spectra of the A2 sample (ARSW). (c) SEM image with (d) EDS spectra of the F2 sample (PRSW). (e) SEM image of the S2 sample (SRSW). (f) EDS spectra of the S4 sample (SRSW).

Initial Vitrification stage. Vitrification is clearly observed in all samples at T > 900°C (Cultrone et al., 2001).

SEM-EDS analysis of the A2 sample (ARSW) is presented in Figure 3b. Quartz minerals, macroscopically observed (Analysis 1), were also detected in the EDS analysis. The presence of feldspar minerals (Analyses 2 and 3), which were not clearly observable microscopically, was confirmed. Elements such as Fe, K, Al, and Si were identified during surface scanning (Analysis 4) conducted via SEM-EDS. The presence of the Fe element is attributed to the mineral hematite (Figure 3b). SEM-EDS analysis was also performed on the F2 sample (PRSW) (Figure 3d). Quartz minerals, microscopically observed (Analysis 2), were corroborated by EDS analysis. Elements like Fe, Ca, Si, and Al were identified in the analysis of the groundmass texture (Analysis 1). This observation suggests the formation of new minerals. In the S4 sample (SRSW), elements such as Fe, Ca, K, Mg, Al, and Si were identified through SEM-EDS analyses. Quartz (Analysis 2) and calcite (Analysis 3) minerals were identified as grains (Figure 3f). Quartz, K-feldspar, and plagioclase were observed as grains. These elemental results align with the temperatures determined by XRPD analyses of the samples.

Chemical analysis

The concentrations of major and trace elements for 22 red slip wares are presented in Table 2. Figure 4 illustrates a comparative analysis of these samples, revealing a distinct separation in

TABLE 2 Chemical analysis results of the samples.

		African red slip ware								Phocaean red slip ware				
Element	**Birim(Ağırlıkça)**	**A1**	**A2**	**A3**	**A4**	**A5**	**A8**	**A9**	**A10**	**F2**	**A6**	**F3**	**F4**	**F5**
SiO_2	%	65.29	63.60	63.24	66.42	65.42	61.85	66.15	65.74	55.99	58.66	57.91	55.37	55.34
TiO_2	%	1.39	1.28	1.22	1.12	1.00	1.24	1.09	1.34	1.00	1.12	1.08	1.03	1.04
Al_2O_3	%	18.89	18.75	17.26	16.85	13.17	18.67	15.56	16.99	16.37	18.46	17.07	17.06	16.63
Fe_2O_3	%	5.80	6.04	5.96	5.53	6.54	5.94	4.95	4.85	6.24	7.01	6.95	6.29	6.59
MnO	%	0.01	0.04	0.05	0.03	0.05	0.04	0.01	0.01	0.05	0.05	0.06	0.05	0.05
MgO	%	1.52	1.66	1.52	1.62	1.81	1.68	1.80	1.14	1.89	2.33	2.17	2.00	1.96
CaO	%	0.71	0.76	0.44	1.63	5.04	0.92	2.00	0.49	7.54	3.04	4.23	7.44	8.11
Na_2O	%	0.63	0.72	0.57	0.67	0.89	0.75	0.73	0.52	0.80	0.96	0.92	0.74	0.92
K_2O	%	2.65	3.00	2.97	2.72	2.21	2.95	2.31	2.22	3.36	3.06	2.98	3.35	3.05
P_2O_5	%	0.12	0.09	0.10	0.11	0.24	0.08	0.30	0.11	0.11	0.13	0.10	0.14	0.13
LOI	%	2.60	2.10	4.20	4.10	3.30	4.70	4.70	4.00	5.20	4.40	4.90	5.30	5.10
Total		***99.62***	***98.04***	***97.53***	***100.79***	***99.69***	***98.82***	***99.61***	***97.42***	***98.54***	***99.23***	***98.35***	***98.76***	***98.93***
Cr	ppm	144.0	151.0	129.0	152.0	104.0	177.0	116.0	119.0	118.0	123.0	127.0	122.0	116.0
Ba	ppm	428.0	494.0	427.0	525.0	686.0	558.0	584.0	499.0	872.0	726.0	744.0	808.0	809.0
Rb	ppm	94.6	110.6	106.5	108.4	74.0	115.9	74.9	81.0	163.5	158.1	150.4	155.1	150.4
Sr	ppm	226.2	207.7	221.5	246.4	234.6	216.5	444.6	160.9	167.4	176.1	182.2	173.6	244.1
Y	ppm	27.7	29.5	28.9	28.8	25.6	30.8	24.4	27.2	24.3	27.5	25.7	25.3	22.8
Zr	ppm	360.4	381.6	422.4	404.5	393.6	396.0	393.1	506.7	228.4	272.6	239.3	248.0	222.5
Nb	ppm	26.3	22.9	21.1	22.5	23.1	22.9	22.0	25.1	18.8	20.1	19.2	20.1	18.5
Th	ppm	19.2	17.3	16.1	16.4	13.7	18.1	15.1	17.1	19.3	20.7	19.9	20.1	18.0
Ni	ppm	131.9	105.4	96.9	159.1	154.1	97.9	118.6	138.5	115.3	123.3	144.3	118.7	133.1
V	ppm	178.0	102.5	114.5	127.6	112.5	125.6	108.2	128.4	111.7	144.3	138.5	142.3	127.9
Hf	ppm	15.2	12.9	13.5	13.4	12.1	13.5	12.5	14.4	9.4	10.9	9.2	8.5	7.9
Cs	ppm	<4.0	<4.0	<4.0	161.6	292.2	202.7	184.0	186.9	<4.0	<4.0	<4.0	<4.0	301.9
Pb	ppm	29.8	27.5	23.7	26.1	20.7	33.1	28.0	25.9	36.9	33.9	30.7	32.7	28.3
Ta	ppm	31.9	21.8	26.4	19.5	20.5	28.8	24.4	17.3	33.1	27.0	24.3	30.7	25.4

TABLE 2 (Continued)

Element	Birim(Ağırlıkça)	African red slip ware A1	A2	A3	A4	A5	A8	A9	A10	Phocaean red slip ware F2	A6	F3	F4	F5
Co	ppm	120.3	109.4	80.3	188.9	173.0	73.4	125.2	174.3	85.2	73.4	126.9	79.6	
U	ppm	4.8	1.5	2.2	2.5	1.7	2.2	1.4	2.2	1.6	1.6	1.2	1.6	2.2
W	ppm	878.4	656.0	487.8	1334.0	1302.0	441.6	991.6	1209.0	492.9	400.2	819.8	465.5	709.8
Ga	ppm	28.2	27.5	25.9	26.3	20.3	28.1	23.8	27.5	23.8	26.9	25.4	25.8	24.7
Cu	ppm	22.1	21.0	19.0	21.9	21.5	20.4	17.4	18.6	30.0	35.9	35.0	33.0	34.9
Zn	ppm	70.4	80.3	77.5	75.4	97.4	82.8	95.5	75.4	87.1	96.3	97.0	98.6	93.2
Se	ppm	<0.5	0.9	0.3	2.4	2.8	<0.5	1.3	2.5	0.8	0.3	1.4	0.5	1.2
As	ppm	7.1	6.1	6.2	7.4	6.3	6.4	6.3	7.5	7.3	3.3	4.9	7.1	7.5
La	ppm	2.0	208.0	310.0	448.0	581.0	480.0	373.0	418.0	497.0	<2.0	580.0	<2.0	582.0
Nd	ppm	140.9	105.8	115.2	114.4	92.9	120.1	107.6	110.5	83.7	85.0	99.6	93.4	69.6

TABLE 2 (Continued)

Element	Sagalassos red slip ware S1	S2	S3	S4	S6	S5	S7	F6	Other F1
SiO_2	49.17	49.54	50.20	50.01	48.64	48.45	49.25	47.32	56.72
TiO_2	1.50	1.50	1.52	1.51	1.48	1.30	1.42	1.22	1.24
Al_2O_3	15.17	16.01	16.18	16.07	15.62	11.88	13.39	11.91	17.49
Fe_2O_3	11.01	11.01	10.91	11.49	11.19	10.95	11.27	10.43	10.47
MnO	0.16	0.17	0.18	0.15	0.15	0.18	0.16	0.16	0.35
MgO	5.00	5.24	5.31	5.19	5.02	10.08	7.49	9.16	1.84
CaO	6.75	5.71	5.61	5.19	5.51	8.31	7.43	7.53	0.87
Na_2O	1.75	2.01	1.81	1.75	1.68	1.36	1.31	1.38	0.50
K_2O	4.10	4.17	4.24	4.29	4.16	2.37	2.73	2.32	4.53
P_2O_5	0.25	0.26	0.29	0.23	0.23	0.18	0.23	0.16	0.17
LOI	5.11	4.38	3.74	4.01	6.22	4.89	5.30	7.00	4.60

TABLE 2 (Continued)

	Sagalassos red slip ware								Other
Element	S1	S2	S3	S4	S6	S5	S7	F6	F1
Total	***99.96***	***100.01***	***99.98***	***99.90***	***99.91***	***99.95***	***99.97***	***98.60***	
Cr	208.5	234.7	236.2	215.2	215.2	215.2	215.2	367.0	180.0
Ba	1024.0	929.0	840.0	766.0	683.0	759.0	611.0	783.0	933.0
Rb	98.5	110.7	110.0	106.8	109.4	77.9	97.2	80.2	143.4
Sr	164.4	156.5	162.3	143.3	154.1	175.7	186.9	184.5	38.9
Y	26.2	28.7	29.2	26.9	28.3	21.3	24.1	20.3	27.5
Zr	207.2	222.8	219.7	202.9	213.3	149.5	173.2	144.1	231.8
Nb	23.9	25.8	25.9	24.9	24.9	17.6	17.6	16.3	22.5
Th	16.7	18.5	17.0	17.7	17.9	11.1	14.0	11.5	17.6
Ni	193.0	202.2	207.6	212.9	203.4	515.9	362.0	475.9	148.5
V	197.5	210.0	227.9	200.0	199.8	172.1	211.7	162.0	166.2
Hf	3.2	5.7	9.1	7.7	7.0	7.9	3.2	7.0	5.0
Cs	288.1	390.8	163.9	<4.0	<4.0	249.4	<4.0	321.3	<4.0
Pb	19.4	18.1	17.6	15.7	17.9	20.6	51.5	21.5	76.2
Ta	29.8	33.5	31.8	27.5	31.8	34.0	32.8	41.2	31.2
Co	77.5	70.5	68.6	102.0	74.6	86.5	72.8	104.1	50.8
U	<0.7	<0.7	<0.,7	1.1	0.7	<1.0	1.0	<1.0	0.5
W	218.3	157.7	191.3	375.8	223.8	185.3	75.0	315.5	183.8
Ga	24.1	25.4	24.9	24.7	24.8	17.9	22.8	16.8	29.2
Cu	63.7	47.8	52.3	51.8	52.2	61.7	70.5	62.7	39.9
Zn	120.8	127.0	123.7	122.8	123.5	110.8	122.1	107.5	142.8
Se	<0.5	<0.5	0.1	0.3	<0.5	<0.5	<0.5	0.5	<0.5
As	1.0	2.3	2.3	2.0	6.4	2.5	4.0	2.6	15.1
La	557.0	787.0	271.0	368.0	381.0	570.0	<2.0	448.0	<2.0
Nd	70.6	79.4	87.8	78.1	77.1	43.4	56.4	41.2	82.2

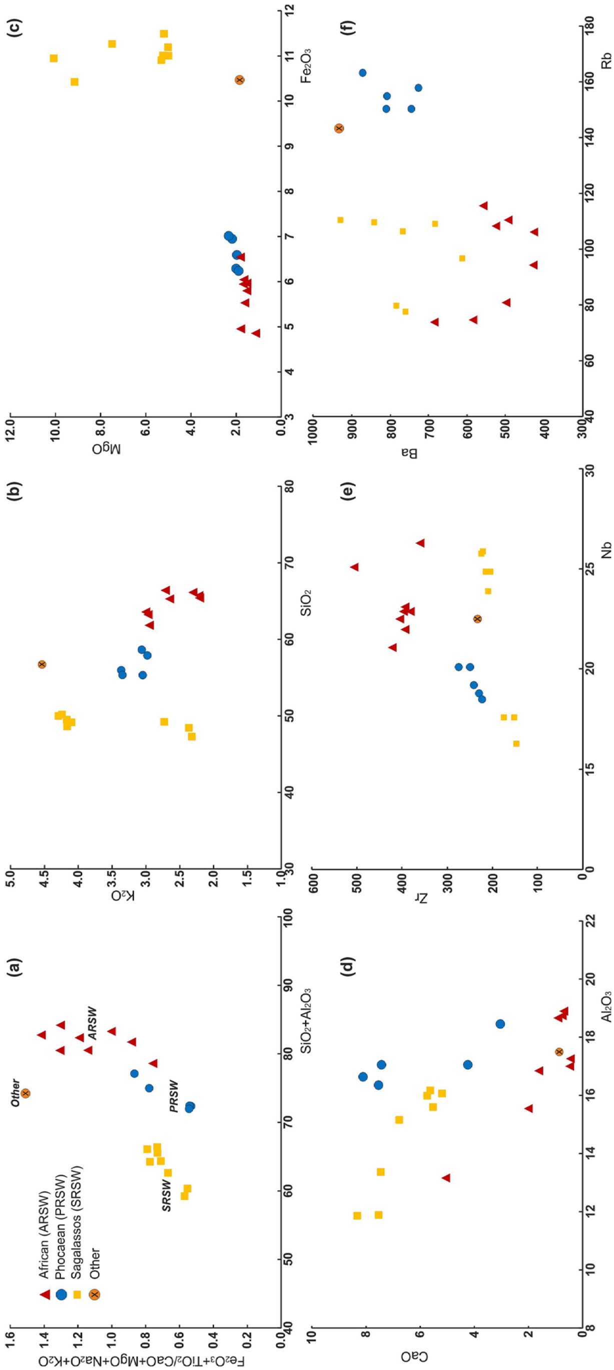


FIGURE 4 Major and trace elements binary diagrams of the red slip wares.

the $SiO_2 + Al_2O_3$ versus $Fe_2O_3 + TiO_2/CaO + MgO + Na_2O + K_2O$ diagram. The lowest $SiO_2 + Al_2O_3$ value was observed in SRSW, whereas the highest was found in ARSW (Figure 4a). The average SiO_2 content is 64.71% in ARSW, 56.65% in PRSW, and 49.07% in SRSW (Figure 4b). Variations in SiO_2 content appear to be directly related to the siliceous mineral composition of the samples. Fe_2O_3 concentrations are similar in ARSW (average 5.70%) and PRSW (average 6.62%), but are notably higher in SRSW (average 11.03%). Elevated Fe_2O_3 levels are attributed to the presence of hematite, as identified in mineralogical analyses. K_2O content averages 2.63% in ARSW and is slightly higher in PRSW at 3.16%. In SRSW, the K_2O content is elevated at 4.19%. Notably, these ratios are slightly below average in three SRSW samples (S5, S7, F6), aligning more closely with ARSW (Figure 4b). Consequently, these three samples have been categorized as a distinct chemical subgroup. MgO content is 1.59% in ARSW and slightly higher in PRSW at 2.09%. In SRSW, the MgO content is significantly elevated, averaging around 5.15%. This level exceeds the subgroup average of 8.91% in SRSW (Figure 2c). The elevated MgO content is particularly evident in SRSW samples. CaO content is similar in both PRSW and SRSW, averaging 6.07% and 5.75%, respectively. This ratio exceeds the subgroup average, registering at 7.76% in SRSW (Figure 4d). This is attributed to the presence of sparry calcite in the samples. Interestingly, these differences observed in the SRSW subgroup were not evident in mineralogical examinations. In the F1 sample, a distinct composition is observed, characterized by high K_2O and Fe_2O_3 content and low CaO levels (Figure 4).

Some trace elements, such as Cr, Zr, Ti, and Nb, are commonly employed as geochemical indicators due to their association with specific petrological characteristics of source rocks (Belfiore et al., 2007; Iordanidis et al., 2009; Kibaroğlu et al., 2011; Mommsen, 2001; Semiz, 2017, 2021). Elemental profiles of these trace elements exhibit similar characteristics across all samples examined (Figure 4e,f). Notable differences were observed in Nb, Zr, and Y, which are considered immobile trace elements (Figure 4e). The highest Zr concentrations were identified in ARSW samples at 407.3 ppm, whereas the lowest were found in SRSW at 213.2 ppm. In PRSW, the Zr concentration is moderate, averaging 242.2 ppm. In SRSW, Zr and Nb show a positive correlation, with concentrations of 213.2 and 25.1 ppm, respectively (Figure 4e).

The highest Rb concentrations were measured in PRSW at 155.5 ppm. In ARSW (95.7 ppm) and SRSW (107.1 ppm) samples, the concentrations are relatively similar (Figure 4f). Ba concentrations are low in ARSW (525.1 ppm) but are closely aligned in PRSW (791.8 ppm) and SRSW (848.4 ppm). Cr and Ni concentrations are comparable in ARSW and PRSW but are elevated in SRSW. Notably, the Ni concentration in the SRSW subgroup exceeds the average. The F1 sample stands out for its high Rb and Ba concentrations, and moderate Zr and Nb levels. These characteristics suggest that it closely resembles PRSW (Figure 4e,f).

DISCUSSION

The classification of samples analyzed in this study, based on their archaeological features, can provide a general framework and offer convenience in subsequent archaeometric analyses. However, classifications derived from archaeometric analyses yield more accurate and precise results. As a result of this study, 22 samples were reclassified (see Table S2). Specifically, the A6 sample, initially considered as belonging to the ARSW group, was associated both petrographically and chemically with the PRSW group. The F6 sample, previously considered part of the PRSW group, was found to be similar to the SRSW group. In light of these findings, new form definitions were established according to the reclassified groups. The F1 sample, however, differed from all groups both mineralogically and chemically. Despite these differences, the F1 sample showed similarities to the PRSW samples in chemical analyses, suggesting closeness in compositional attributes.

Red slip wares distinguished in terms of paste, slip, and shape, and dated to the Late Roman Period, were discovered at excavation sites in Germanicia. Among these samples, red-slipped bowls and plates from Sagalassos, Africa, and Phocaean were identified. Due to the location of the settlement area within the boundaries of a modern settlement, the architectural structures and artifacts from the ancient city have undergone significant deformation. The presence of fill soil in the area complicates the tracking of the stratigraphic sequence. No artifacts aiding in the dating of the ceramics were encountered at these levels. During the dating phase of the ceramics, other finds were used as references. Typological distinctions were made based by Poblome (1999) for the Sagalassos group, which is among the Late Roman Period red-slipped ceramics found in Germanicia. Finds from the African and Phocaean groups were categorized by Hayes (1972).

Based on major oxides and trace elements, all samples were compared with red slip ware analyses conducted in previous studies for ARSW in Tunisia (Mackensen & Schneider, 2002), PRSW in Phocaean (Civelek, 2021; Semiz, 2024), and SRSW in Sagalassos (Braekmans et al., 2011) and Tripolis (Semiz, 2017; Semiz et al., 2018). This comparison aims to determine whether there are chemical similarity or differences. It is well known that even samples with highly characteristic features can show variations within their own regions or countries. In this context, the objective was to explore the geographical origins of the samples under examination in this study.

ARSW

The first study on ARSW was conducted by Waage in 1933, based on ceramics found in the Agora of Athens. Waage (1933) classified Late Roman Ceramics imported from Egypt into categories A, B, and C. In 1958, Lamboglia (1958) further divided these ceramics into Terra Sigillata A, C, and D. Hayes (1972) coined the term 'African Red Lined Group' for the first time in 1972. These ceramics, produced in North African workshops—particularly in Tunisia (Neuru, 1987)—from the late first century AD to the seventh century, were widely used in Mediterranean settlements (Hayes, 1980). The typical microfabric of ARSW consists of a highly fired, iron-rich, noncalcareous clay with fine inclusions of quartz, having grain sizes up to approximately 0.2 mm (Mackensen & Schneider, 2002). Our samples were compared based on chemical analyses with production centers of ARSW from the third to seventh centuries AD in northern Tunisia (specifically, EI Mahrine and Henchir el Biar) and central Tunisia (Sidi Marzouk Tounsi) (Figure 5). The most prevalent forms (Hayes 58 B, 59A/B, 61A, 61 transitional, 62A, 63, 67, 76A/B, and 67/71, 73A/B) are found in EI Mahrine and Henchir el Biar up to the mid-fifth century (Mackensen & Schneider, 2002). From approximately the mid-fourth to the mid-fifth century, forms Hayes 50B, 58A, 60, 63, 68, 69, 72AB, 74, and 75 were also produced at Sidi Marzouk Tounsi (Mackensen & Schneider, 2002). Although the density of ceramics belonging to Hayes Form 67 is notable in Germanicia, one ceramic from the Hayes Form 61A group was also identified. These ceramics are dated to the fourth and fifth centuries AD in Germanicia.

The potteries from EI Mahrine are characterized by an average silica content of 70.72% SiO_2. Samples from Henchir el Biar also show a similar composition, with an average SiO_2 content of 72.49%. In contrast, the samples from Sidi Marzouk Tounsi have a lower average SiO_2 content of 64.72%. The samples from Germanicia display an average SiO_2 content of 64.71%, which is higher than all the other examined samples and closely associated with those from the central Tunisia (Sidi Marzouk Tounsi) region (Figure 5a). The Fe_2O_3 and Al_2O_3 contents in the examined samples are higher than those in the EI Mahrine and Henchir el Biar samples but

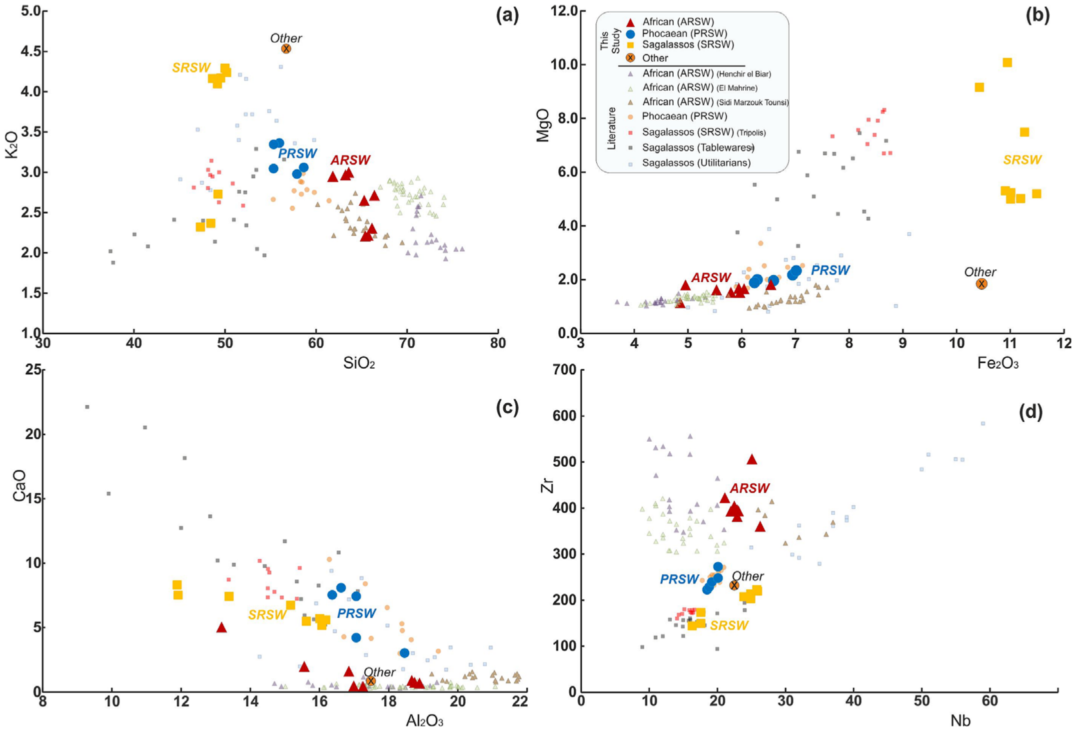


FIGURE 5 Comparative binary diagrams of the Caesarea Germanicia RSW with analytical data of red slip wares from other regions/countries. *Source*: ARSW in Tunisia (Mackensen & Schneider, 2002), PRSW in Phocaean (Civelek, 2021; Semiz, 2024), and SRSW in Sagalassos (Braekmans et al., 2011) and Tripolis (Semiz, 2017; Semiz et al., 2018).

lower than those in the Sidi Marzouk Tounsi samples (Figure 5b,c). The MgO and CaO contents are relatively similar to all samples. Based on binary diagrams, the examined samples are clearly distinguishable from the PRSW and SRSW groups. These samples closely resemble those reported in previous studies, particularly those from the central Tunisia (Sidi Marzouk Tounsi). This resemblance is especially notable in their high TiO_2 and Al_2O_3 values. Consequently, it is hypothesized that the ARSW samples found in Germanicia may have originated from different source areas within the central Tunisian region.

PRSW

It was first described by Waage in 1933 as a group of ceramics found in the Athenian Agora. These ceramics were initially termed ‘Late Roman C’ based on their clay and slip characteristics (Waage, 1933). In 1980, Hayes introduced the term ‘Phocaean red slip ware’, in addition to ‘Late Roman C’, based on bowl fragments discovered in Phocaean (Hayes, 1980). To date, no archaeometric studies on PRSW have been published; existing research primarily focuses on the archaeological features of PRSW (Civelek, 2006; Fırat, 2012, 2013). Our team initiated the first archaeometric study on PRSW, which is still ongoing. Civelek (2021) defined the Phocaean Coastal Road red slip ware in his study and briefly discussed their archaeometric features. Further details are currently in the publication stage (Semiz, 2024). This study includes a comparison of these archaeometric data with our samples.

Phocaean Coastal Road red slip ware emerged at the end of the fourth century AD, gained prominence in the mid-fifth century AD and continued to be produced until the mid-seventh century AD. These wares were extensively used in the Eastern Mediterranean during the fifth and sixth centuries AD, and are dated slightly earlier in and around Asia Minor (Hayes, 1972). This form group, considered an opponent to Cyprus red slip ware in the Eastern Mediterranean, has been utilized in numerous settlements since the mid-fifth century AD (Hayes, 1972).

The paste color of Phocaean Coastal Road red slip ware ranges from yellowish-red to dark red (Civelek, 2021). PRSW samples found in Germanicia show similar colors. Although only a few specimens of Hayes Form 11 were observed, numerous fragments of Forms 3 and 10 were identified (Civelek, 2021). In Germanicia, two specific forms—Hayes Form 3C and Form 3E—were unearthed. The Form 3C group was dated to the fifth to sixth centuries AD, and the Form 3E group to the late the fifth to sixth centuries AD. The SiO_2 content in PRSW is higher than that in SRSW but lower than that in ARSW (Figure 5a). It is noted that these samples closely align with or overlap those in studies conducted in previous years. Diagrams based on trace elements indicate that the examined samples correspond with PRSW, suggesting that these samples are of Phocaean origin. Although ceramics of this form are limited in number in Germanicia, they provide evidence of trade relations with Western Anatolia.

SRSW, used from the Augustan Period until 700 AD, has a widespread distribution across various regions and geographies (Willet & Poblome, 2015). This ware group was extensively utilized in ancient Anatolian settlements, including those in Pisidia, Cilicia, Pamphylia, Lycia, Ionia, Lydia, and Phrygia, as well as in overseas countries like Italy, Tunisia, Libya, Egypt, Syria, and Israel along the Mediterranean coast (Poblome, 1999; Willet & Poblome, 2015). Despite Sagalassos being inland, it exported to different regions during the Roman Period. Potters from Sagalassos produced wares suitable for land transportation, enabling a wide geographical distribution (Ok, 2018a, 2018b).

It has been stated that SRSW is primarily divided into two categories: daily-use bowls and tableware. The SRSW found in the ancient city of Tripolis were found to be similar to Sagalassos tableware. Germanicia specimens fall within an area close to that of the Tripolis specimens. In the K_2O–SiO_2 correlation diagram, SiO_2 contents are similar to other samples, but differences are observed in K_2O contents (Figure 5a). K_2O values of the samples in Germanicia are slightly elevated, suggesting that the K_2O content may originate from illitic clays. Variations are noted between sample groups in MgO and Fe_2O_3 diagrams. MgO content is slightly lower in Tripolis samples, which are similar to Sagalassos tableware, whereas Fe_2O_3 content is higher across all groups (Figure 5b). These differences in MgO content may be attributed to the presence of pyroxene and chlorite minerals in the samples (Braekmans et al., 2011; Degryse & Poblome, 2008). A negative correlation is observed in the Al_2O_3–CaO binary diagram. As Al_2O_3 content increases, a decrease is noted in the CaO content of the samples. However, in the Germanicia samples, it was determined that they fall within an area close to both Sagalassos and Tripolis samples (Figure 5c). Additionally, differences are observed in the trace element contents of SRSW, distinguishing daily-use pots from tableware (Figure 5d). Germanicia specimens are also plotted in an area close to the tableware.

Braekmans et al. (2011) mention that various clay deposits have developed in different valley systems in the region. In this context, it is considered that primarily chlorite and smectite-type clays from the Çanaklı plain were used for SRSW production. These clays are mainly composed of illite and chlorite, as well as kaolinite, and lesser amounts of smectite, plagioclase, K-feldspar, quartz, pyroxene, and biotite. Due to these clay compositions, it is considered that these materials were likely transported during sedimentation processes and are chemically known to contain very high MgO levels. Semiz (2017) and Semiz et al. (2018) reported that a group of red slip wares found in Tripolis are Sagalassos productions. Germanicia specimens appear to be closely related to both Sagalassos tableware and Tripolis specimens. It was concluded that Germanicia specimens were produced from clay sources available in the Çanaklı plain and are dated to the first half of the fourth to sixth centuries AD. From this perspective, the 200-year difference between the samples was interpreted as stemming from the use of the same sources but with some additives, as the trace element contents are largely similar, but there are some differences in major element contents such as K_2O, Fe_2O_3, and TiO_2.

In summary, when evaluating the red slip wares from the Late Roman Period in Germanicia, it can be suggested that the city met its ceramic import needs through trade with Western Anatolia and Africa, primarily via the port of Tarsus. With Sagalassos, which is located further inland, land transportation appears to have been prioritized. The city was economically robust during this period and sourced its needs from various cities. The presence of these ceramics proves Germanicia's investment in the ceramic trade network during the Late Roman Period.

CONCLUSION

The red slip wares excavated in the ancient city of Germanicia (southeastern Anatolia), examined in this study using multiple archaeometric methods, are basically divided into three groups: ARSW, PRSW, and SRSW, all dated to the Late Roman Period. The A6 sample belongs to PRSW, whereas the F6 sample was found to be similar to SRSW, both petrographically and chemically. The F1 sample, on the other hand, differs from all groups, both mineralogically and chemically (see Figure S2). ARSW is characterized by abundant and coarse quartz inclusions, and less plagioclase, mica (muscovite), and iron oxidation components. ARSW has very high SiO_2, Cr, Ni, and lower CaO, Fe_2O_3, Ba, Cr, Ni contents. These contents (especially SiO_2) can be related to Sidi Marzouk Tounsi from Central Tunisia. PRSW contains quartz, secondary calcite, and lesser amounts of mica and amphibole minerals. PRSW has very high Rb contents. For SRSW, it was determined that the samples contain fine silicate inclusions and mineralogically include quartz, biotite, sparry calcites, and opaque minerals, as well as pyroxene minerals in smaller amounts. SRSW contains high Fe_2O_3, CaO, K_2O, and MgO, and these contents (especially MgO) are related to Çanaklı clays. As a result of XRPD and SEM-EDS analyses, it was determined that all samples were fired at moderate to high temperatures (approximately 800°C for ARSW; 850–900°C for PRSW and SRSW).

Germanicia, located in the Commagene Region in southeastern Anatolia (Kahramanmaraş), was situated on regional trade routes during antiquity. The discovery of ceramic groups belonging to different production centers in the city indicates that Germanicia engaged in ceramic trade with various regions and cities in ancient times. In antiquity, Germanicia had trade routes with important port cities like Tarsus and Aigeai. The road route from Antiochia and connected to Issos in the ancient period with the road from Tarsus, reaching Zeugma in the east and Germanicia in the northeast (Demir, 2016). Products brought to the Cilicia Region via land and sea routes were connected to the Mediterranean and Central Anatolia via main trade routes (Durukan, 2015). Germanicia's commercial relations with the western (Phocaean) and inner parts of Anatolia (Sagalassos) in the Late Roman Period can be traced through different ceramic groups. Apart from Anatolia, its commercial activities with North Africa have also been revealed by studies. Although red slip wares dating to the Late Roman Period are limited in number in Germanicia, it is important to note that the city was not indifferent to the use and trade of these ceramics.

As a result of our archaeometric investigation of the red slip wares, which were defined according to archaeological findings, it was determined that the ancient city of Germanicia did not have local production and that the ceramics were imported from different geographies (African, Phocaean, Sagalassos). When evaluating the red slip wares from the Late Roman Period (fourth to six centuries AD) in Germanicia, it can be suggested that the city met its import ceramic needs through trade with Western Anatolia and Africa, especially from the port of Tarsus. With Sagalassos, which is located further inland, it can be interpreted that land transportation was preferred.

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DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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