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ARCHAEOMETRIC INVESTIGATION ON RED SLIP OF URARTIAN POTTERY

Atilla Batmaz[1] and İlker Özkan[2]

[1]Ege University, Department of Archaeology, 35100, Bornova, Izmir, Turkey
[2] Dokuz Eylül University, Torbalı Vocational School, Industrial Glass and Ceramics Department, Torbalı, Izmir, Turkey

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Corresponding author: İlker Özkan (ilker.ozkan@deu.edu.tr)

ABSTRACT

The primary objective of the present work is to make a comparison between the red glossy slip of Urartian pottery (commonly known as Urartian red polished ware) and local clays by conducting a variety of examinations. As a result of these investigations, the authors will suggest the most likely clay sources for ceramics and the slip that may have been used by the Urartian potters. Four samples from Ayanis Fortress have been characterised from the chemical, mineralogical, morphological and petrographic points of view. Scanning electron microscopy, optical microscope, X-ray diffraction, energy dispersive spectrometry, chemical analysis and colour measurement investigations have been carried out on the ceramic body and red glossy slip to determine their characteristics and technological features. In addition, three local clays were characterised by chemical, mineralogical and petrographic analyses. Test pieces made from local raw material were fired in a traditional updraft mud-brick kiln in order to better understand the paste and red-slip-making processes of Urartu. The results obtained from the different analyses demonstrate significant similarities between ceramic samples and fired clay test pieces. It may be concluded that it is possible these local clays were used in production of Urartian red glossy ceramics.

KEYWORDS: Urartian red glossy ware, archaeometric investigation on pottery, experimental archaeology, local clay sources

1. INTRODUCTION

The Urartian Kingdom was one of the most predominant kingdoms in the Near East between 9th-7th century B.C. (Çilingiroğlu, 1997). Its territory extended from Eastern Turkey to Northwestern Iran and Transcaucasia and incorporated high mountain fortresses and highlands during the Middle Iron Age. The highlands incorporate various landscapes, and for months of every year their valleys, highlands and roads are covered with snow. Almost all information we have about Urartian culture so far has come from archaeological excavations on the kingdom's fortresses and graveyards. Although the culture is best known for its metalworking technology and skills, a group of ceramics, referred to as red polished ware, which were produced by copying metal vessels (Kroll and Zahlhaas, 1976, 85; Van Loon, 1966, 32), is also a fruitful area of study for archaeologists. This group of pottery is an indicator of the Urartian presence and is unearthed in almost all Urartian fortresses. The fact that the pottery is found in small quantities in fortresses when compared with other ware groups reflects that is demanding to make, and its elegant appearance, with its shiny red surface, leads us to believe that the ware may have been produced under the control of ruling elites and reserved for their own use. The common forms are mostly tableware, composed of jugs, plates, bowls, and goblets, but most famous is the one-handled trefoil jug. The body generally has light brown-red colours and low-density inclusions. The glossy surface has diverse red tones due to different firing environments, slip compositions and/or locations of the pots relative to one another in the kiln.

The common characteristic and indicator of the pottery is its red and glossy slip. Although it is generally believed that the glossiness came from the highly manual polishing process using tools such as stone, bone or metal, in some cases, the slip composition and firing methods must have been decisive in obtaining the desired red colour and glossy finish. In fact, there is various contemporary or non-contemporary similar class of red slipped and glossy pottery traditions in the Mediterranean from Neolithic to Roman times with their refined ferruginous clay suspensions on the surface of the ceramic body such as Red Lustrous Ware in Late Bronze Age (Knappett et. al., 2005) or Roman Terra Sigillata (Picon et. al., 1971, 1975; Tite et. al., 1982). However, our preliminary observations indicate that the surface treatments of red slipped glossy Urartian pottery bears some specifications.

The key element or method used to obtain the desired brightness is not yet certain, but several suggestions have been made. S. Kroll (1970) noted that the slip has a glaze-like, glossy finish and suggested that this resulted from quartz crystals, while E. Akça (Akça et. al., 2010) mentioned that the slip contains a "completely and extensively vitrified matrix and was probably produced from low-melting hydrous mica." Alternatively, S. Kapur (Kapur et. al., 1991) suggested for Hatti ceramics that developed firing technologies using basaltic raw materials could yield highly vitrified ceramics. Lastly, H. Kapmeyer (2005) thinks that elements in the slip such as lithium or boron, which melt in low temperatures, act as fluxes and thus may be responsible for the vitrified surface.

Although some studies on the characterisation of the Urartian red glossy ceramics based on experimenting with different techniques have been reported in the literature (Kleinmann, 1976; Speakman et al., 2004; Kapmeyer, 2005; Erdem et al., 2008; Akça et al., 2010), detailed study of the production technology by comparing local clays has not until now been undertaken. B. Kleinmann (1976, 64 ff.) focused on the mineralogical aspects of the pottery from Bastam, E. Akça et al. (2010, 233 ff.) performed some chemical and morphological analysis (ICP-AES and SEM) of several sherds from sites in Eastern Turkey such as Aznavurtepe (Ağrı), Çavuştepe (Van) and Van Fortress (Van). Kapmeyer (2005, 313 ff.) conducted a number of analyses such as SEM, EDX and REM to answer questions related to how the glossy surface of the ceramic was produced, what the chemical composition of the core and the slip were, and whether these factors were uniform throughout the Urartian territories. A very few analyses have also been undertaken on the clay of the ceramics. Speakman et al. (2004, 119 ff.) did neutron activation analysis (NAA) on the Urartian Pottery from Eastern Anatolia and detected mobility from region to region. Erdem et al. (2008, 2486 ff.) tried to characterise the Iron Age pottery from Eastern Turkey through the use of laser-induced breakdown spectroscopy. The present work was motivated by the fact that no comprehensive analysis and experimentation on local clays has previously been carried out in the area of understanding the production technology of red glossy slip of the Urartian pottery and identifying the clay sources that might have been used by the makers. In order to fill this gap in the literature, the present study is designed to: (i) determine the characteristics of the Urartian ceramics, their slips and local clays obtained from the Van and Bitlis region (ii) compare the characteristics of the two. The results will also enable us to comprehend better the qualities and composition of local clays used in pottery manufacturing.

2. MATERIAL AND METHODS

In the present work we would like to place extra emphasis on the material from Ayanis Fortress, from which we selected four representative Urartian pottery samples to examine, coded as S1, S2, S3 and S4 (Table 1, Figure 1, Figure 2). Ayanis Fortress is thought to have been one of the most important cultic and administrative centres of the kingdom in the seventh century BC. It was established by the Urartian king Rusa II (685–653 BC) on a rocky hill on the eastern shore of Lake Van, across from the volcanic mountain, Süphan(Çilingiroğlu 2013). The investigations suggested that the Ayanis fortress was dated to 673/2 B.C. (Çilingiroğlu, 2013; 2016), and it must have collapsed before 653 BC, likely as a consequence of an earthquake (Çilingiroğlu 2002: 484–488; Çilingiroğlu 2011: 339, 346). All the samples selected are red slipped glossy ceramics and some of their characteristics are described in Table 1.

In addition, three clay samples local to the related region were studied (Figure 3). These are a) green clay (2 Y 7/3 pale yellow), which is called Van Light due to its colour (VL), b) brown clay (10 YR 5/3 brown), which is called Van Dark (VD), derived from Van, and c) red soil (2.5 YR 4/6 red), which is called Bitlis Soil (BS) (locally called Avusku) and is obtained from Bitlis, Eastern Turkey (Figure 4). According to the ethnological data obtained from potters in the Bardakçı Village (Van), the ideal firing temperature of VL is 900–1000˚C. It takes on white tones at 1050˚C, and becomes brick reddish at 850˚C. In the village, VD is mostly mixed with green clay to produce cookware (locally called *güveç*). It reaches the ideal red colour at 600–700˚C. The colour turns yellow at 800˚C and the clay starts to deform at 900˚C.

Table 1. Description of the samples on the basis of form, colour, firing, production and matrix characteristics.

Sample	Description
S1	Bowl (Inverted rim), reddish-orange fabric, red slipped (10 R 4/8), well fired, wheel made, poorly sorted, vitrified matrix texture, low grain/matrix ratio, low porosity with isolated pores.
S2	Jar (groove-rimmed), reddish-brown fabric, red slipped (10 R 4/8), medium fired, wheel made, poorly sorted, vitrified matrix texture, low grain/matrix ratio, low porosity with isolated pores.
S3	Bowl (ring base), yellow-brown fabric, red slipped (10 R 4/6), very well fired, wheel made, moderately sorted, vitrified matrix texture, low–medium grain/matrix ratio, low porosity with isolated pores.
S4	Jug (trefoil), yellow-brown, red slipped (10 R 4/6), very well fired, wheel made, poorly sorted, vitrified matrix texture, low–medium grain/matrix ratio, low porosity with isolated pores.

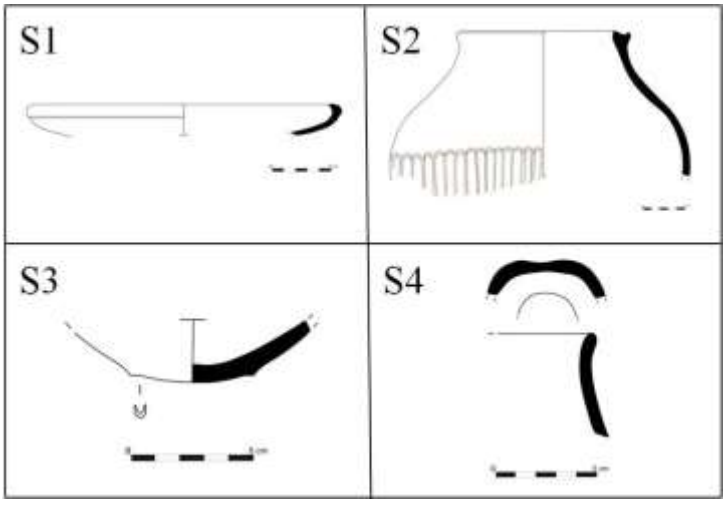

Figure 1. Drawings of the examined potsherds.

Figure 2. Representative images of ceramic sample coded S2 (a) Obverse (b) Reverse and (c) Section.

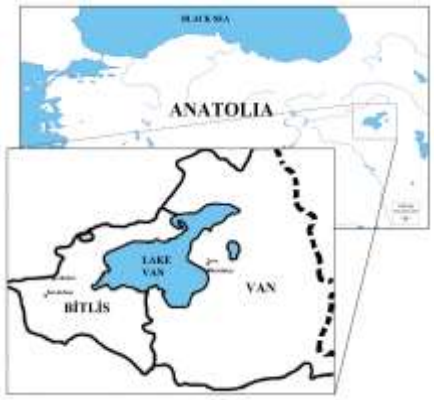

Figure 3. Sampling areas.

Figure 4. Analysed soil samples from Van and Bitlis.

Chemical analyses were conducted on the clay samples and the glossy surface layer of the Urartian samples. Their chemical compositions were analysed using ICP-MS at Bureau Veritas Mineral Laboratories, Canada. The major and minor oxides (SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5, MnO, Cr_2O_3) and trace elements (Ba, Ni, Sr, Zr, Y, Zr, Nb, Sc) were determined. The results with minimum detection limits (MDL) are given in Table 2. The test pieces taken from the clay samples were fired at 800˚C, 850˚C and 900˚C. The phases present in the bodies of the ceramic samples, glossy surface layers and fired clay samples were identified by X-ray diffraction (XRD) using a Rigaku Model diffractometer with monochromatic Cu Kα radiation. XRD patterns were obtained by scanning 3 to 90˚, with a goniometer speed of 2˚/min, operating at 40 kV and 36 mA. The microstructures of the samples were investigated under a JEOL-JSM 6060 Scanning Electron Microscope (SEM) and an optical microscope. The SEM worked under an acceleration potential of 20 kV, with a 40 µm spot size and a 100 c/s live time for EDS analyses. Chemical compositions of the particular regions from the investigated cross sections were determined by an energy dispersive X-ray spectrometer, EDS (IXRF System 500) attached to the SEM. Colour measurements of the samples were performed using a portable colorimeter 3NH (model NH-310) as well as a Munsell soil chart (2000 edition) of the type frequently employed by archaeologists to determine the colours of ceramics and soil.

Slipped test pieces (Figure 5), measuring 4x4 cm and made of green (VL) and brown clays (VD) from Van, coded 1A and 1B, were fired at 1050 °C in Bardakçı Village, where traditional pottery making is being continued by only one active workshop. The aim was to obtain the most accurate and comparable outputs. As Bitlis soil has not enough plasticity for shaping a vessel, it was merely used for the slip.

Figure 5. Photographs of test pieces fired at 1050 °C.

Firing was performed in the totally traditional way in the mud-brick updraft kiln of potter Osman Eşme. The kiln was composed of two chambers: a combustion chamber in its lower section, and a pottery alcove on the top. The ceramics are laid on a perforated platform so that the fire can properly reach the upper section.

Thin section analysis was performed on four Urartian ceramics and two clay test pieces (1A and 1B). Thin sections were obtained by fixing the sherds on glass lamellae and then reducing their total thickness to 30 µm by chafing. Prepared sections were examined under the optical microscope through the use of plain and polarised light. Table 2 lists all the analyzed samples.

Table 2. List of the all analyzed samples and analyses performed. (CA: Chemical Analysis, OM: Optical Microscope, XRD: X-Ray Diffraction, SEM: Scanning Electron Microscope, EDS: Energy Dispersive Spectrometry, CM: Colour Measurement).

Sample code	Description	CA	OM	XRD	SEM	EDS	CM
S1	Ceramic sample from a bowl.		X	X	X	X	X
S2	Ceramic sample. A part from a jar.		X	X	X	X	X
S3	Ceramic sample. A part from a bowl.		X	X	X	X	X
S4	Ceramic sample. A part from a jug.		X	X	X	X	X
GSL	Glossy surface layer of the pottery samples.	X	X	X	X	X	X
VL	Green clay that is called Van Light due to its color.	X		X			
VL	Fired at 800°C			X			X
VL	Fired at 850°C			X			X
VL	Fired at 900°C			X			X
VD	Brown clay that is called Van Dark due to its color.	X		X			
VD	Fired at 800°C			X			X
VD	Fired at 850°C			X			X
VD	Fired at 900°C			X			X
BS	Bitlis soil.	X		X			
BS	Fired at 800°C			X			X
BS	Fired at 850°C			X			X
BS	Fired at 900°C			X			X
1A	Test piece made of VL clay.		X				
1B	Test piece made of VD clay.		X				

3. RESULTS AND DISCUSSION

Chemical compositions of the clay samples and glossy surface layers (GSL) are shown in Table 3. It should be reminded that the burial environment of archaeological ceramics may modify the chemical composition of their bodies. In particular, solutions migrating from the soil to buried samples can deposit extraneous matter on the ceramic body (Antonelli et al., 2014). The clay samples and surface layers consist mainly of SiO_2 and Al_2O_3, which correspond to about 50-68% of the total due to the presence of clay minerals and quartz. In addition, all the samples consist of a significant amount of iron oxide, which accounts for the reddish colour after firing. VL and VD have higher CaO content than BS due to the presence of calcareous materials. Na_2O and K_2O quantities are in the moderate ranges that are indicators of the presence of illite and feldspathic minerals. The similarity between BS and GSL is clearly seen in terms of major oxides and some trace elements.

Table 3. Chemical analyses results (MDL: Minimum Detection Limit, VL: Van Light Clay, Van Dark Clay, BS: Bitlis Soil, GSL: Glossy Surface Layer).

Element or element oxide concentration	Unit	MDL	Sample Code			
			VL	VD	BS	GSL
SiO_2	(%)	0.01	49.70	38.21	47.90	46.21
Al_2O_3	(%)	0.01	12.00	11.92	20.73	20.30
Fe_2O_3	(%)	0.04	6.46	7.09	11.49	10.54
MgO	(%)	0.01	5.07	4.85	1.37	1.37
CaO	(%)	0.01	8.91	14.44	0.51	2.60
Na_2O	(%)	0.01	1.86	1.19	0.32	1.46
K_2O	(%)	0.01	1.99	2.04	1.93	3.36
TiO_2	(%)	0.01	0.80	0.91	1.60	1.81
P_2O_5	(%)	0.01	0.17	0.22	0.25	0.17
MnO	(%)	0.01	0.08	0.12	0.21	0.17
Cr_2O_3	(%)	0.002	0.040	0.027	0.041	0.021
Ba	ppm	5	212	282	341	884
Ni	ppm	20	206	99	187	195
Sr	ppm	2	256	587	77	289
Zr	ppm	5	154	135	268	541
Y	ppm	3	23	21	35	120
Nb	ppm	5	16	19	27	37
Sc	ppm	1	15	19	23	17
LOI	ppm	-5.1	12.7	18.7	13.4	-

The results of XRD analyses of the bodies, glossy slip of the potsherds, clays and clays fired at elevated temperatures are given in Table 4, respectively. Quartz, illite, albite, hematite, diopside/augite, chlorite, calcite, dolomite and microcline phases were identified from the XRD spectra of the samples. Glossy surface layers and bodies have similar phases except microcline phase.

Representative SEM and optical microscopic cross section images of bodies and glossy surface layers and the corresponding EDS spectra taken from the glossy surface layers and bodies are given in Figure 6-9. For all samples, the bodies have porosities in their structure, whereas surface layers are more compact. The bodies have isolated pores in the clay matrix.

The optical microscopic images of the GSL on all samples revealed an average thickness of about 0.125 mm; a very compact structure with no voids and a greater degree of sintering compared to the body. This indicates that the slips were applied to body surfaces in a form of suspension in order to make a uniform slip layer. Also, it can easily be seen that the colour of the GSL on all samples is different from the colour of the body. These data clearly indicate that finer clay, with colorant and fluxes, was used in the production of the GSL than was utilised for the body. Additionally, no cracks were observed on the GSL of the samples, which shows there was no mismatch between the thermal expansion coefficients of the bodies and the glossy slip.

Table 4. XRD results of the samples.

Sample	**Minerals/Phases**
S1-Body	Quartz, illite, albite, hematite, diopside/augite
S2-Body	Quartz, illite, albite, hematite, diopside/augite
S3-Body	Quartz, illite, albite, hematite, diopside/augite
S4-Body	Quartz, illite, albite, diopside/augite
S1-Glossy Surface Layer	Quartz, illite, hematite, diopside/augite, albite, microcline
S2-Glossy Surface Layer	Quartz, illite, hematite, diopside/augite, albite, microcline
S3-Glossy Surface Layer	Quartz, illite, hematite, diopside/augite, albite, microcline
S4-Glossy Surface Layer	Quartz, illite, hematite, diopside/augite, albite, microcline
BS	Quartz, illite, kaolinite, albite, hematite, chlorite, dolomite
VL	Quartz, illite, kaolinite, albite, hematite, chlorite, calcite
VD	Quartz, illite, kaolinite, albite, hematite, chlorite, calcite
VL (fired at 800˚C)	Quartz, illite, calcite, hematite, albite
VL (fired at 850˚C)	Quartz, illite, hematite, albite
VL (fired at 900˚C)	Quartz, illite, hematite, albite
VD (fired at 800˚C)	Quartz, illite, albite, hematite
VD (fired at 850˚C)	Quartz, illite, albite, hematite

VD (fired at 900˚C)	Quartz, illite, albite, hematite
BS (fired at 800˚C)	Quartz, illite, albite, hematite
BS (fired at 850˚C)	Quartz, illite, albite, hematite
BS (fired at 900˚C)	Quartz, illite, albite, hematite

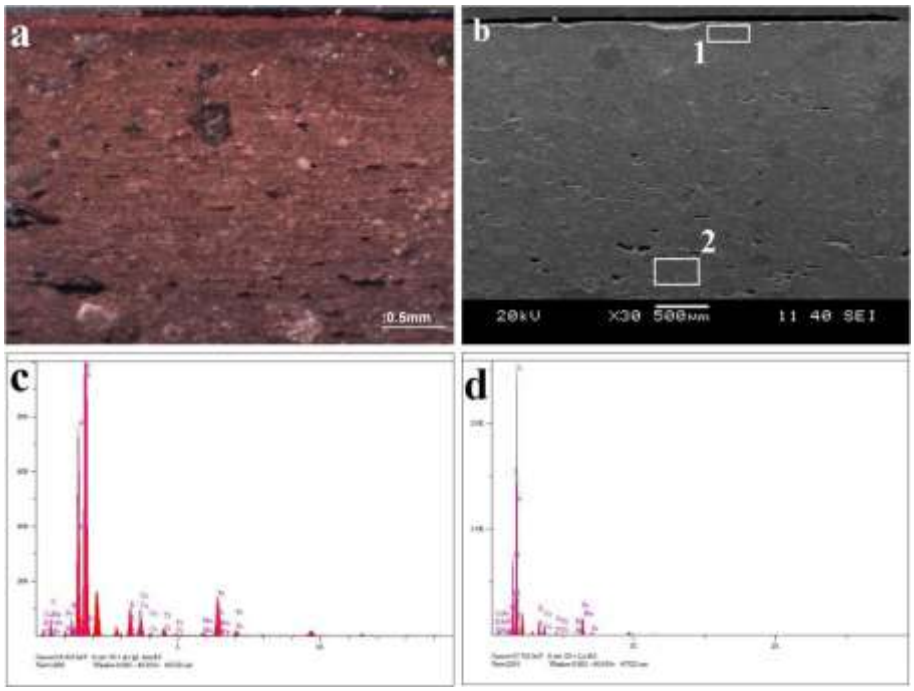

Figure 6. Cross sectional (a) optical and (b) SEM micrographs of S1, EDS spectra of (c) area 1 and (d) area 2.

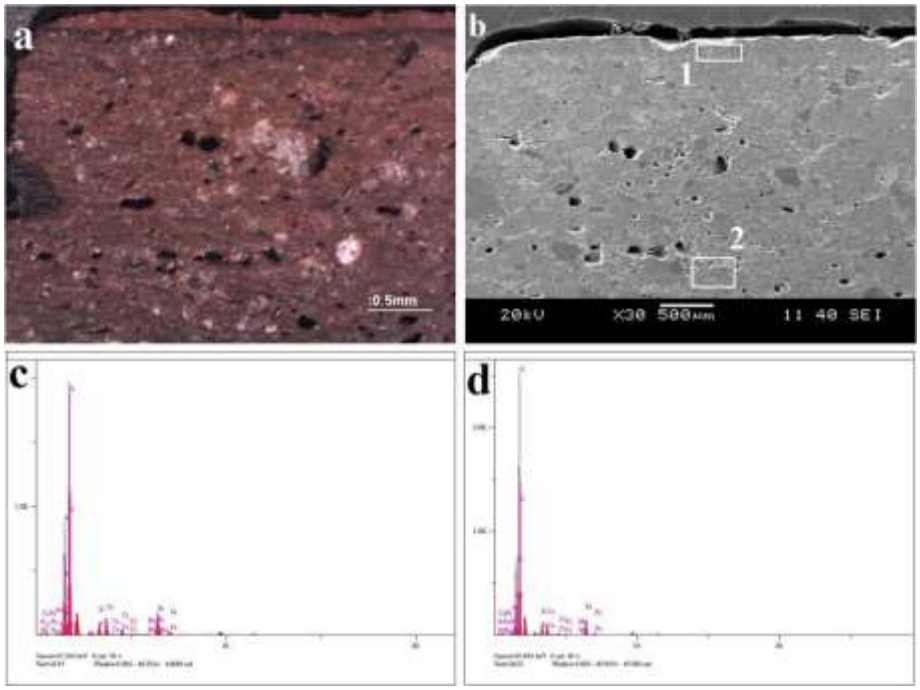

Figure 7. Cross sectional (a) optical and (b) SEM micrographs of S2, EDS spectra of (c) area 1 and (d) area 2.

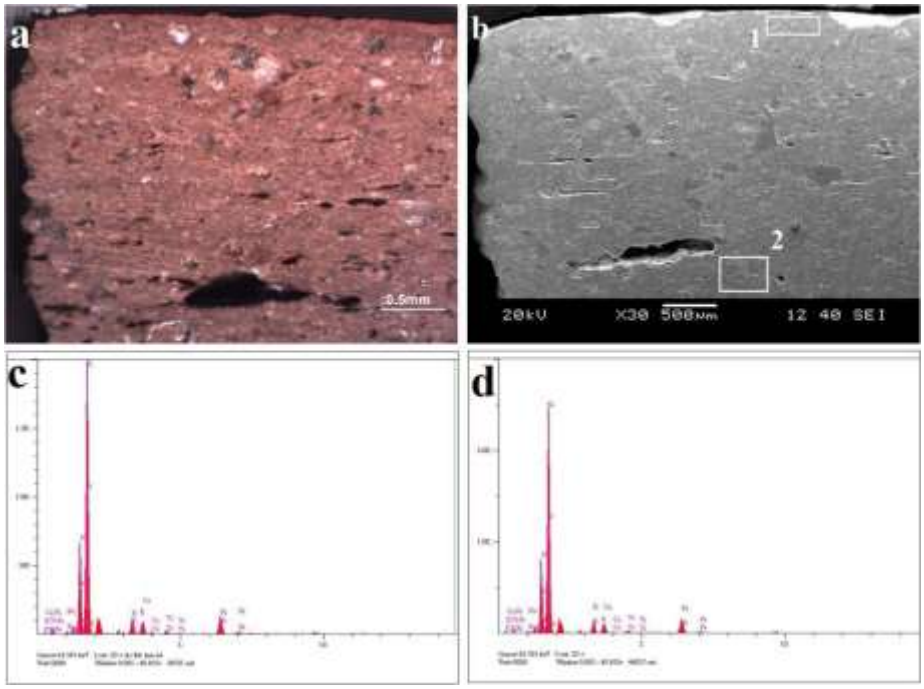

Figure 8. Cross sectional (a) optical and (b) SEM micrographs of S3, EDS spectra of (c) area 1 and (d) area 2.

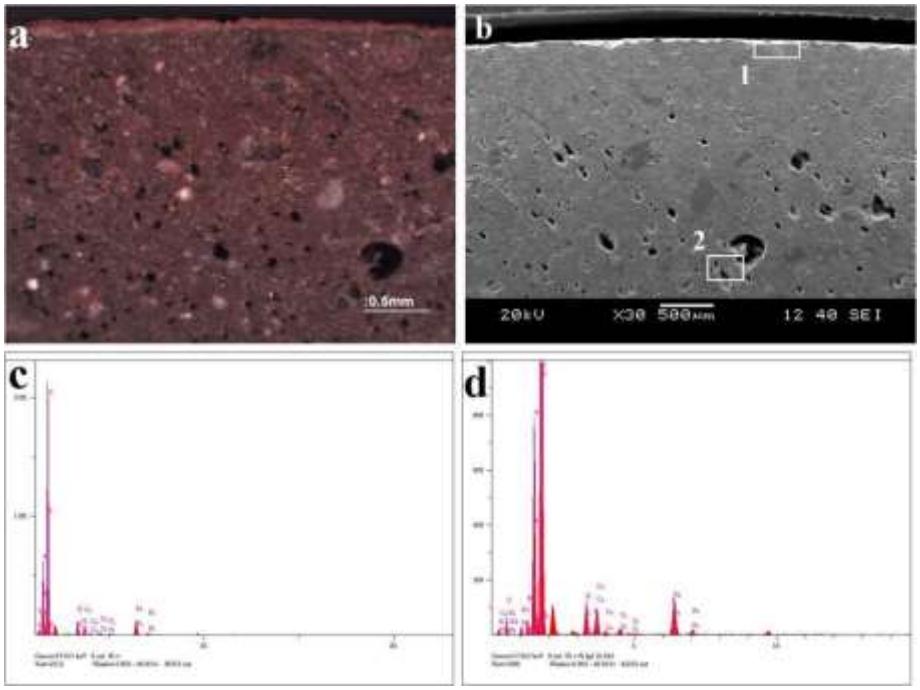

Figure 9. Cross sectional (a) optical and (b) SEM micrographs of S4, EDS spectra of (c) area 1 and (d) area 2.

Table 5 lists the semi-quantitative EDS analysis results in terms of elements and oxides. Elemental compositions of the body and GSL are important for evaluating the production technology used in the ceramic samples under investigation. Both the body and GSL have similar elemental components, but in different ratios (Table 5). According to these data, iron oxide seems to be the major colorant of the GSL. The amount of iron (originating from hematite) varies between 7.894 and 10.319 wt.% for bodies and from 8.027 to 9.367 wt.% for the slip. These results are compatible with Kapmeyer's study on the Urartian ceramics from Bastam Fortress at Iran and Toprakkale Fortress at Van. According to Kapmeyer, the iron content of the Toprakkale ceramics varies between 9.55 and 13.77 wt.% for slip and 10.83 and 13.50 wt.% for bodies. On the other hand, the iron content of Bastam ceramics reaches as high as 22.90 wt%. The iron content of slip is higher than for the bodies; therefore, it is reasonable to think that addi-

tional iron-bearing minerals were used to obtain the colour of the GSL. Also, the Na and K values of the slip are higher than for the bodies. This indicates that Na- and K-bearing minerals (such as Na_2CO_3 and K_2CO_3) were used as deflocculants during the preparation of the suspension for the surface application.

Table 5. Semi-quantitative EDS analysis results taken from the body and GSL of the investigated samples in terms of (a) elements and (b) oxides.

(a)	Elements (wt.%)								
	Na	Mg	Al	Si	K	Ca	Ti	Fe	O
Figure 6b- GSL	0.838	0.890	9.578	27.723	3.134	2.337	0.737	8.194	46.568
Figure 6b- Body	0.776	0.875	8.442	29.065	3.405	1.959	0.746	7.894	46.838
Figure 7b- GSL	0.680	0.961	9.216	27.834	3.279	2.262	0.830	8.416	46.522
Figure 7b- Body	0.677	0.888	9.196	27.845	3.260	2.538	0.862	8.223	46.512
Figure 8b- GSL	0.824	0.782	8.871	28.671	2.797	2.472	0.668	8.027	46.839
Figure 8b- Body	0.482	0.736	10.632	25.025	2.423	2.676	1.339	10.319	45.827
Figure 9b- GSL	0.653	0.937	9.187	27.272	3.255	1.857	0.784	9.367	46.279
Figure 9b- Body	0.517	0.991	10.019	26.753	3.017	1.829	0.845	9.078	46.372

(b)	Oxides (wt.%)							
	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	Fe_2O_3
Figure 6b- GSL	1.129	1.476	18.096	59.308	3.775	3.270	1.229	11.716
Figure 6b- Body	1.046	1.451	15.951	62.179	4.101	2.741	1.245	11.286
Figure 7b- GSL	0.917	1.593	17.413	59.545	3.950	3.165	1.384	12.033
Figure 7b- Body	0.913	1.472	17.375	59.569	3.926	3.551	1.437	11.756
Figure 8b- GSL	1.110	1.296	16.761	61.336	3.369	3.459	1.114	11.477
Figure 8b- Body	0.649	1.220	20.089	53.536	2.919	3.744	2.234	14.753
Figure 9b- GSL	0.881	1.554	17.358	58.342	3.921	2.599	1.308	13.393
Figure 9b- Body	0.697	1.643	18.931	57.232	3.634	2.559	1.409	12.979

Thin section analysis reveals that plagioclase and feldspar grains are very common in the examined samples (Figure 10). Both large and small grains of feldspar were observed on all pottery samples and also on traditionally prepared and fired test piece 1B. Sample 1A is very poor in rock and mineral grains; only a large feldspar grain was detected on that sample. The feldspar grains observed in thin section analyses are not sharp edged, suggesting that feldspar grains were not grinded and added to the bodies, but rather occurred in the original clay source.

The shapes and distribution of the particles dispersed throughout the matrix are similar for all pottery samples. This similarity shows that a particular clay source was likely to have been chosen for the production of these ceramics and/or similar raw material preparation processes were used. Volcanic rock fragments were identified in samples S3 and 1B, indicating a possible raw material source.

Although the thickness of the thin section can change the colour to some extent, matrix colour is mainly an indicator of the firing atmosphere. Red indicates oxidative firing conditions. As a result of oxidation, hematite minerals are seen in the structure. It was observed that samples S2 and S1 have a red-brown colour, while samples S4 and S3 are yellowish-orange. Sample 1A is in shades of yellow and the colour of 1B is red-brown.

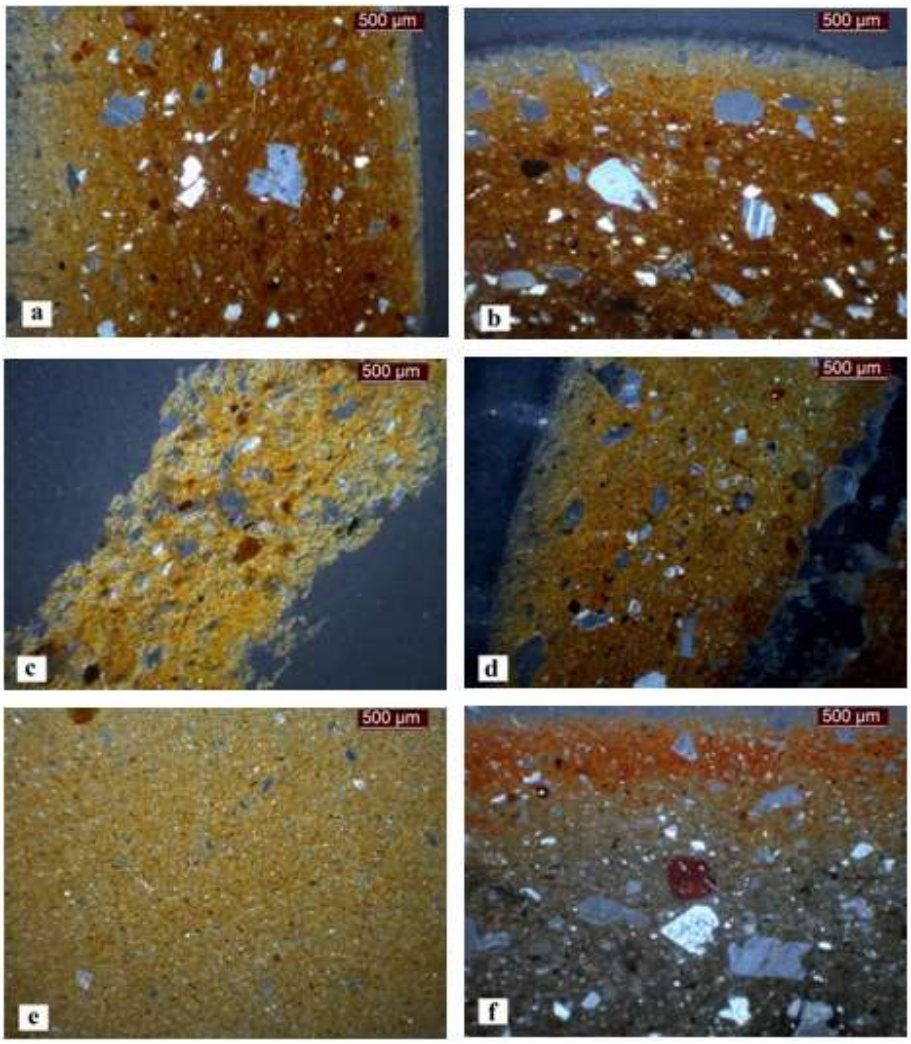

Figure 10. Optical microscopy images from thin sections of (a) S1, (b) S2, (c) S3, (d) S4, (e) 1A and (f)1B.

Table 6. Colour measurement values.

Sample Code		Chromatic Coordinates		
		L	a	b
S1	Body	45.99	18.24	23.20
	Glossy Surface Layer	42.35	26.50	26.11
S2	Body	47.49	18.6	22.92
	Glossy Surface Layer	40.19	26.81	24.52
S3	Body	46.12	16.99	23.15
	Glossy Surface Layer	32.87	24.68	18.99
S4	Body	44.89	21.24	25.26
	Glossy Surface Layer	36.71	28.11	23.87
VL clay	800˚C	51.21	16.93	27.89
	850˚C	53.56	19.90	31.12
	900˚C	55.05	21.63	32.21
VD clay	800˚C	49.69	19.06	25.98
	850˚C	49.18	20.85	25.47
	900˚C	52.36	21.60	25.13
BS clay	800˚C	32.21	28.12	26.94
	850˚C	36.41	28.32	29.78
	900˚C	39.70	25.16	28.11

Table 6 shows the colour measurements of four pottery sherds and three local soil samples fired at different temperatures. Colour values were evaluated by 'L', 'a', and 'b' values along the chromatic coordinates ('L' value indicates the lightness scale, where 0 is black and 100 is white; 'a' value indicates the red–green scale, where positive values are red, negative values are green and 0 is neutral; 'b' value indicates the blue–yellow scale, where positive values are yellow, negative values are blue and 0 is neutral).

'L' values of the bodies are higher than for glossy slip, so the colours of the bodies are lighter than those of the surfaces. On the other hand, higher 'a' values of glossy slip indicate that slip have a stronger reddish colour than bodies; this may have been intensified by using additional iron-bearing minerals. The 'L' and 'a' values of the fired clay samples increased with higher temperatures. When the 'a' value is taken into account, it can easily be seen that VD clay fired at 850˚C is the most promising option for production of the body. In addition, 'L' and 'a' values of BS clay fired at 850˚C fit the values for glossy surface layers.

The characterization studies give clues to the production technology of Urartian red glossy ceramics. The presence and absence of some mineralogical/phase contents in the samples constitutes very important data for estimating firing temperatures. Illite was the only clay mineral identified in body and slip. Illite mica structure breaks down at 900–1000˚C. Quartz and feldspars can persist up to 1000˚C. In addition, diopside/augite may be generated at 800–900˚C. During heating decomposition and phase transformation, processes take place. The calcite peaks that can be seen in unfired samples disappeared in the fired samples due to thermal decomposition. Dolomite has the decomposition with two stages that begins at around 650˚C and continues up to 900˚C. Therefore dolomite peaks are not observed for the fired samples of BS. Although the illite structure breaks down at 900–1000˚C, it was observed that the intensity of illite peaks becomes lower as the temperature increases. Hence the BS clay sample has high Fe_2O_3 content (Table 3); hematite peaks with higher intensity are seen at all temperatures. Thus it is reasonable to think that the firing temperature was probably not over 900˚C. All the samples contain hematite, which is evidence that all the ceramics are fired in oxidative condition. The diopside/augite phase was identified in the samples. This phase may be generated at 800–900˚C. Porosities in the body of the ceramic samples reveal that the ceramics were unlikely to have been fired at higher temperatures. Furthermore, the colour values of the local clays fired at 850˚C are very close to the colour values of the bodies. Kapmeyer indicated that the surface gloss disappeared and dullness increased when clay was fired at 900˚C (Kapmeyer, 2005). Similarly, test pieces 1A and 1B fired at 1050˚C justified this conclusion with their dullness. When these data are taken into account, the firing temperature of the Urartian glossy red ceramics should not be higher than 850˚C.

Elemental composition of the glossy surface layers indicated that those layers contained higher Fe, K and Na ratios. The optical microscopy images suggest that the thicknesses of the surface layers are not uniform (Figure 6-9). In addition, the colours of these layers are reddish and darker than the bodies. The glossy surface layers are observed not only on open wide surfaces, but also on inner curved surfaces. As mentioned in Kapmeyer's study (2005), some spiralling signs and bumps were observed on the surface layers. These observations suggest that polishing was not applied; a suspension was probably prepared and spread over the body. Minerals such as Na_2CO_3 and K_2CO_3 are used as deffloculant to suspend the solid particles in the liquid. In addition, oxides of Na and K act like flux in the batch, helping to form the sintered and glossy slip. This also explains the higher Na and K ratios.

During the cross sectional observations, there were black regions (black cores) in the bodies of some samples (Figure 2c). This indicates the presence of carbonaceous materials in the utilised clay. During firing, air is needed for combustion of materials containing carbon. It needs to penetrate the interior, and this takes time. Also, a sintered glossy surface layer decelerates the penetration of air and stops the decarbonisation. As a result, black deposits form in the bodies.

The comparison results between pottery and raw materials give useful data. The colour analyses indicated that the local clays VL and VD are significant candidates for the clays used to produce the bodies of the ceramics. Thin section analyses also confirm this view. The fired VL clay sample has a similar microstructure to S4 and S3. The fired VD clay sample has similar microstructure to S2 and S1. When the red slip is taken into account, the chemical compositions of GSL and BS are very similar in terms of both major oxides and some trace elements (Table 3). This strong similarity gives rise to the thought that BS may have been used for the surfaces. Additionally, due to its high Fe_2O_3 and very low CaO content, with suitable additives BS clay might have been used for the suspension that forms the red slip when it is applied over the body.

The Bitlis region, from where BS was obtained, is situated on the western and southwestern shores of Lake Van, in the lake basin. This region, which was

an integral part of the Urartian kingdom, was also an important state centre. As regards geomorphology, Bitlis province and its districts are rich in iron ore as seen on the metallogenic map of General Directorate of Mineral Research and Exploration (MTA) (Figure 11). It can be deduced that the clay from the region is suitable for making pottery, as the towns of Günkırı and Kavakbaşı in Bitlis continue to produce pottery in traditional ways. Moreover, BS has long been used for slip in the production of traditional pots in those towns (Figure 12). Therefore, it is quite reasonable to think that the Urartians may also have used BS, which is rich in iron and very suitable for making slip, with its very thin grain and soluble structure.

Figure 11. Metallogenic map of the around Lake Van. Iron is located in areas coloured red (adopted from MTA). The map was retrieved from http://www.mta.gov.tr/v2.0/haritalar/maden_haritalari/metal/28.html, on 06/05/2016.

It has been determined that raw material is usually located in the range of 1–7 km from the workshops that manufacture pottery (see, for detail, Arnold, 1989, 50).

The distance between Van, the centre of the kingdom, and the towns of Bitlis from where BS procured is 125 km as the crow flies. Although such a distance could be thought quite considerable, there are two reasons why it would not have been an insurmountable problem for the Urartian Kingdom: the first is that as stated above the Bitlis region was not only within the domination area of the kingdom but also one of the important Urartian province which possessed slip soil rich in iron for red slipped glossy Urartian pottery; the second is that the amount of soil to be obtained would not have to be produce the pottery itself, but only the slip. The total amount of soil required for the slip would be much less for transportation and would not be a great challenge for a powerful kingdom with organised labour and state resources.

Figure 12. Jugs from Kavakbaşı village slipped with BS (Avusku)

4. CONCLUSIONS

In this study, four representative Urartian pottery samples from Ayanis Fortress and three clay samples from the local region were characterised using chemical, mineralogical, morphological and petrographic analyses.

The phases obtained through XRD analyses revealed that the firing temperature of the pottery

samples is unlikely to have been over 900˚C and that an oxidation atmosphere was probably formed during firing. The optical microscopic images of the glossy slip obtained from all samples indicated that a very compact and uniform structure, with a larger degree of sintering compared to the body, was formed over the vessels. The difference between the colours of these layers and of the bodies clearly indicates that finer clay, with colorant and fluxes, was used in the production of the GSL than for the bodies. The higher content of Fe, Na and K elements obtained from EDS analyses also supports this finding.

Petrographic data obtained from thin section analyses reveal the similarities between the pottery samples and the test pieces produced from local clays. Samples S1 and S2 showed similarity to 1B while Samples S3 and S4 showed similarity to 1A. It is reasonable to think that these clays were used as raw material for the bodies. Chemical analyses and colour measurements show a strong relationship between GSL and BS.

To conclude, the results of the experiments described here add significant details to our knowledge of the production technology of red slipped glossy Urartian pottery. Promising data obtained from different analyses reveals significant similarities between ceramic samples and fired clay test pieces. It may be concluded that the local clays could have been used in production of Urartian ceramics with red glossy slip.

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