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PROVENANCES AND PRODUCTION TECHNIQUES OF THE SO-CALLED “PORT SAINT SYMEON WARE” (13TH-EARLY 14TH CENTURY AD) FROM KINET HÖYÜK (CILICIA, TURKEY): WITNESSING INTERACTIONS IN MEDIEVAL NORTH-EASTERN MEDITERRANEAN

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ABSTRACT

One of the most widely distributed ceramics in north-eastern Mediterranean during the thirteenth century AD was the ceramic commonly called “Port Saint Symeon Ware”, whose iconography reflects multi-cultural influences and traditions. Samples coming mainly from the archaeological site of Kinet Höyük (Cilicia, Turkey), as well as from several sites in the Mediterranean, enabled us to define the output of two production centres of Port Saint Symeon Ware, based on archaeological data and on WD-XRF analyses of the ceramic bodies. The materials and recipes used for their decoration – glazes, slips and colorants – were investigated by SEM-EDS. The results show that the two production centres had very different scales of diffusion, but share similar decoration techniques that might be considered as standardized. They consist in the application of a transparent high-lead glaze on a “hybrid” vitrified clayey slip, rich in angular siliceous inclusions, whose features suggest technical influences of the Islamic tradition. The potters of the Port Saint Symeon Ware seem to have selected inclusions and potassium-rich clays in order to obtain off-white slips which are visually and technically close to synthetic ones.

KEYWORDS

Port Saint Symeon Ware, Thirteenth century AD, north-eastern Mediterranean, Mediterranean trade, Islamic pottery production techniques, vitrified quartz-rich slip, WD-WRF, SEM-EDS

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INTRODUCTION

During the medieval period, “the movement of skilled workers and goods generated new fashions, new markets demands, and the manufacture of new products” (Jacoby, 2004: 110). Studying the so-called Port Saint Symeon Ware, one of the most distributed tablewares in the eastern Mediterranean during the thirteenth century (Figure 1a), could enable us to illustrate this phenomenon. Produced in several workshops located in Cilicia and in the region of Antioch, this type of ceramic emerged from a crossroads region where Muslims and western and eastern Christians converged (Stern, 2012). Because of its geographical location, this region offered special advantages for trade since it was located at the northeast Mediterranean edge, at the junction of routes to Anatolia, the Black Sea, the Levant, Egypt, Mesopotamia, Persia and the East. In that respect, the production of the Port Saint Symeon Ware made it an authentic expression of the cultural, social, religious and economic interactions that took place in the medieval north-eastern Mediterranean. From its wide distribution and from its stylistic and iconographic diversities, this tableware provides information relating to both trade and technologies in this region during the thirteenth century.

The present study, mainly based on a corpus of Port Saint Symeon Ware discovered in the last medieval phases at Kinet Höyük, follows the research conducted by Redford and Blackman (2005). Through instrumental neutron activation analyses (INAA) of the ceramic bodies, they defined several productions of Port Saint Symeon Ware including one that was from the region of Kinet Höyük. Other archaeometric studies on samples of Port Saint Symeon Ware from various sites of the Mediterranean confirmed that at least one workshop widely exported this type of ceramic. These studies focused also on the decoration techniques via the analysis of slips and glazes, and showed that the latter consisted in the application of a high-lead glaze over a slip very rich in quartz inclusions reminiscent of stonepaste (Capelli et al., 2005; 2006; 2007; Capelli and Cabella, 2007), a technology of Islamic tradition. Following these previous studies, our paper first proposes investigations into provenance issues based on the analysis of ceramic bodies to gain insight into the organization of production and distribution of Port Saint Symeon-related Wares. In the second section devoted to the analyses of the elements of decoration, we present the technical traditions that could be associated with the Port Saint Symeon Ware’s manufacturing technology.

THE PORT SAINT SYMEON WARE

The most common and characteristic form of Port Saint Symeon Ware consists of hemispherical bowls of standard size and shape, with a ledge rim and a slight ridge at the joint between the body and the rim, and a low ring base (Stern, 2012). For the decoration, potters used the sgraffito technique, incising the main motifs in the slip that covered the surface, and then emphasizing the incised patterns by motifs painted in yellow-orange, brown, green and

sometimes dark purple. The whole decoration was then covered with a transparent glaze (Figure 2). The iconography consists of floral, astrological or heraldic patterns, of human and animal figures, and fantastic creatures, within which Seljuk, Mongol, Christian and Islamic stylistic influences and traditions may be seen (Lane, 1938; Blackman & Redford, 2005; Stern, 2012). This unique multicultural decorative program, generally of secular nature, made this type of ceramic a commercial product accepted by a wide variety of consumers from different geographical and religious backgrounds (Redford, 2012).

The archaeological evidence show that Port Saint Symeon Ware was manufactured in several centres mainly concentrated on the Cilician coast and in the region of Antioch: al-Mina (Lane, 1938), Antioch (Waagé, 1948), Misis (Hild & Hellenkemper, 1990), Kinet Höyük and Epiphaneia (Blackman & Redford, 2005) (Figure 1b). Researchers commonly use the term Port Saint Symeon Ware because this group of ceramics manufactured at different centres was first defined at Port Saint Symeon/al-Mina (Stern, 2012), but it would be more appropriate to use the notion of “Port Saint Symeon Ware Family”. Through the maritime trade that was experiencing a boom in the Mediterranean (Stern, 2010), mainly stimulated by the Italian Republics, the Port Saint Symeon Ware became one of the most widely distributed glazed tableware during the thirteenth century, especially in the Frankish sites of the Levantine coast, but also on Muslim-held inland territories (Figure 1a).

The most extensive analytical study of Port Saint Symeon Ware was carried out by Blackman and Redford (2005). They undertook INAA on 159 ceramic samples discovered mainly at Kinet Höyük, but also at al-Mina and Epiphaneia, as well as on examples from museum collections (Blackman & Redford, 2005). Based on the analysis of the ceramic bodies, five chemical groups were defined; two of them - groups 2 and 4 - mainly included Port Saint Symeon Ware samples. The site of al-Mina was proposed as the production site of samples in group 2, based on archaeological and stylistic grounds, and on the inclusion in this group of seven out of eight samples discovered at al-Mina. Group 4, the largest one, includes local reference samples from the two production sites of Kinet Höyük and Epiphaneia, and was interpreted as the regional production of workshops which “seem to have used a similar if not the same clay source” (Blackman & Redford, 2005).

A distinction between samples from group 2 and group 4 might be considered through the quality of their decoration: the Port Saint Symeon Ware ceramics from group 2 “found at Port Saint Symeon and at Kinet tend to exhibit both more complex iconography and more skilled execution of decoration than those (...) assigned to local production at Kinet” (Blackman & Redford, 2005).

Since the vast majority of the Port Saint Symeon Ware samples of these two groups were discovered in the late thirteenth and early fourteenth centuries contexts of Kinet Höyük, Blackman and Redford (2005) suggested that this ceramic type continued to be produced in al-Mina after the Mamluk conquest - the fall of Antioch and of the town of Port Saint Symeon/al-Mina to the Mamluk army dating to 1268 - and that its production in the region of Kinet started after this event.

RESEARCH QUESTIONS AND SAMPLING

The present study follows on those carried out by Blackman and Redford, and by Capelli, Cabella and Waksman, with a dual objective enabling us to focus on both the economic context and the production technology.

First, new provenance studies were carried out based on chemical analyses of the ceramic bodies using wavelength-dispersive X-ray fluorescence spectrometry (WD-XRF), and on an extensive corpus of comparative chemical data on eastern Mediterranean pottery in the Lyon laboratory database (CNRS, UMR 5138). Forty-five samples from thirteenth and early fourteenth century contexts of Kinet Höyük (Blackman & Redford, 2005), including two biscuit-fired wasters, and one sample from Epiphaneia, were selected for chemical analysis in Lyon, within the two groups previously defined by Blackman and Redford (2005) as the productions of al-Mina and Kinet region (see Table S1 in the additional supporting information for the concordances between the excavations' and laboratories' samples ids). On the one hand, we intended to integrate in the Lyon database, which already includes the chemical composition of about 4000 Eastern Mediterranean medieval ceramic samples, two new reference groups corresponding to production sites of the Port Saint Symeon Ware Family. At the same time, it was the opportunity to propose a detailed chemical definition of these groups, including elements not determined by INAA and the composition of individual samples, as the publication by Blackman and Redford (2005) only provides the means and standard deviations of the chemical groups. On the other hand, it was the opportunity to reconsider these groups using other data related to the same region, and to compare them to data on Port Saint Symeon Ware samples from Lebanon, Israel and Cyprus, Italy and the South of France, related to the regional and long-distance diffusion of the ware, respectively (Capelli et al., 2005; 2006; 2007). The latter combination of data, based on samples from both production and consumption sites, was meant to build a larger framework for understanding the organization of production of the Port Saint Symeon Ware Family, and of its distribution in the Mediterranean.

Second, a focus on the production techniques completed this provenance study. Its objective was to define the technologies and materials used by potters to produce the Port Saint Symeon Ware decoration layers, namely the slip, the glaze and the colorants. Fifteen samples from the two productions were analysed with a SEM-EDS. Through these analyses, we intended to answer two main questions: i) Were there any technological differences regarding the decoration technique between the two productions?; ii) How the various eastern and western influences, already observed from a stylistic point of view (von Wartburg, 2003) and possibly from a technological one as well (Waksman, 2014), are reflected in the decoration techniques? This new study aimed to verify whether potters used the stonepaste technology of eastern tradition to produce Port Saint Symeon Ware decoration.

METHODS

Elemental analysis of the ceramic bodies and statistical treatments of the data

WD-XRF analyses were carried out in Lyon (CNRS UMR 5138) using a Bruker S8 Tiger spectrometer for the analyses of Kinet Höyük samples, and a Bruker SRS 3400 spectrometer for the previous analyses. Samples are cut out with a diamond-coated saw, and glazes and slips, when present, and an external layer, whose chemical composition is more liable to be altered by the burial environment, are removed. After heating at 950°C (removal of water, volatile elements, organics), cooling and grinding, 800 mg of ceramic powder is mixed with 3200 mg of flux (lithium metaborate and tetraborate). The mix is heated to liquid state in a gold and platinum crucible, then cast into a bead. Analyses are carried out on these homogeneous beads, of fixed geometry, which correspond to a mean chemical composition representative of the initial material. Twenty-four elements are quantified, after calibration of the set-up using 40 geological standards (CRPG, USGS, NIST, British Chemical Standards, etc.). The calibration is regularly checked using three in-house pottery standards.

Out of the 24 elements quantified, 17 are usually taken as active variables in multivariate statistical treatments used to classify samples into groups of similar chemical composition. These include major and minor elements in ceramics (MgO, Al₂O₃, SiO₂, K₂O, CaO, TiO₂, MnO, Fe₂O₃) and trace elements having various geochemical behaviour (V, Cr, Ni, Zn, Rb, Sr, Zr, Ba, Ce). Classifications are carried out by hierarchical clustering analysis, applied to standardized data, using euclidian distance and average linkage (e.g. Picon, 1984). Interpretation in terms of productions and workshops however requires further examination of the initial individual chemical compositions, taking into account various geochemical, technological and analytical factors (e.g. Waksman, 2017).

Microstructures and elemental analyses of the coatings

To analyse the ceramic glazes and slips, samples were embedded in a polyester resin, cut in a cross section in order to expose all the layers (Figure 4a), polished up to a 0.25 µm diamond paste and then carbon coated for SEM-EDS analyses. Prior to coating with carbon, the cross-sections were observed under a binocular microscope with magnifications ranging from 10x to 115x.

The glaze analyses were carried out with a SEM (Zeiss ultra plus Field Emission) at the Koç University Surface Science and Technology Centre (KUYTAM) in Istanbul. The study of the microstructures was mainly performed using backscattered electron (BSE) images that differentiate various phases according to the atomic numbers of their elementary content. Elemental compositions were determined by energy-dispersive X-ray spectrometry using a Bruker XFlash EDS 5010 detector with 123eV resolution. All measurements were operated at

15kV acceleration voltage in 60 seconds by setting the working distance at about 10 mm. Standardless quantification was performed using a PAP correction method of the intensities. The Bruker ESPRIT 2 Microanalysis Software was used for data acquisition and evaluation, and the reliability of the results was tested by measuring reference glasses and geological standards (Corning Brill B, C and D, DR-N). Concentrations are given as an average of three to five measurements on different zones selected within the regions of interest of the vitreous part, avoiding the weathered areas and the slip or body interfaces.

PROVENANCES ISSUES

The classification of the samples based on the chemical compositions of the ceramic bodies (Figure 3) shows two main groups, and a pair of samples on the right-hand side of the diagram (BYZ638, BYZ702). The latter differ from the others especially due to their lower iron and titanium contents (Table 1).

All the samples considered have calcareous pastes (Table 1). The two main groups both show high magnesium, chromium and nickel contents, related to the ophiolitic, ultrabasic, geological formations of the region (General Directorate of Mineral Research and Exploration, 2002a; 2002b), but differ in the range of concentrations of these elements. The “Kinet region” group, corresponding to workshops located in the area of Kinet Höyük (cf. *infra*), has much higher concentrations (the mean values, calculated without some marginal higher ones mentioned in table 1, are about 12 % MgO, 750 ppm Cr, and 750 ppm Ni), when compared to the “al-Mina?” group, probably from al-Mina (cf. *infra*; mean values about 6 % MgO, 400 ppm Cr, and 250 ppm Ni). Such differences remind, to a lesser extent, those observed between productions of late Roman amphorae LRA1, from Rhosos/Arsuz on the southern shore of the Iskenderun bay, and from Seleucia-in-Pieria/Samandağ, the antique harbour located a few kilometres from al-Mina (Figure 1b) (Waksman et al., 2004). This trend may be explained according to the pattern proposed by Picon while studying workshops on Samothrace (Karadima et al., 2002). The unsorted detrital material from ultrabasic rocks in narrow coastal plains, in Rhosos/Arsuz and to a lesser extent in Kinet Höyük, would contribute high contents of MgO, Cr, Ni. In contrast, the influence of the ophiolites on clay beds located at the mouth of the Orontes river (al-Mina, Seleucia-in-Pieria) would be less pronounced, as it would be mixed with other, alluvial, components.

The first main group (“Kinet region”) corresponds to group 4 in Blackman and Redford (2005). It contains the two local reference samples for the production of Kinet Höyük (biscuit-fired samples LEV944, LEV948, Figure 3), but also includes a sample from the nearby site of Epiphaneia, attested archaeologically as a production site of Port Saint Symeon Ware as well (LEV941, Figure 3; Blackman & Redford, 2005; Eger, 2008). Following Blackman and Redford (2005), we do not consider this group as local to Kinet Höyük *stricto sensu*, but rather

as the output of workshops located in the same area and exploiting clay resources belonging to the same geological formations.

The second group, that we provisionally called “al-Mina?”, contains samples from Blackman and Redford’s group 2 (2005). They interpreted it as al-Mina’s production as it includes, in their study, samples from Woolley’s excavations at al-Mina, where wasters of such wares had been found (Lane, 1938). However, as no actual wasters were part of their sampling, we consider its identification to al-Mina’s production as likely, but still to be confirmed. It was also not possible to determine from their paper if the samples actually found at al-Mina have a high probability of membership to their al-Mina group (Blackman & Redford, 2005, group 2). This group also includes museum examples, which presumably correspond to the “main” Port Saint Symeon Ware.

Our results support this view, and define this main group more accurately thanks to samples coming from well identified archaeological contexts. They confirm the wide diffusion of this production, both in the eastern (Paphos, Beirut) and in the western (Genoa, Marseilles) Mediterranean, as most of the samples coming from these various sites are included in the “al-Mina?” group (Figure 3). However, the latter is not very homogeneous, and some of its samples may be misclassified, especially samples whose contents in MgO, Cr, Ni are higher and closer to those of the “Kinet region” group (Table 1). The potential contribution to the group of another workshop located in the region of Antioch and its harbour - or from Antioch itself (Waagé, 1948) - should still be kept in mind at this stage, and would request further research. At any rate, the general picture of the “al-Mina?” group is one of a workshop, or cluster of workshops, which exported long distance - its output being found especially in harbours and distributed through maritime trade - and which contributed a large part of the imported glazed wares in Levantine coastal sites such as Acre (Stern, 1997; 2010; 2012). It contrasts with the “Kinet region” group which seems, based on the sampling considered, to have met with an exclusively regional market (Blackman & Redford, 2005).

Intermediate scales of diffusion may have existed as well, as the analyses provide clues for another workshop, represented by two samples from Paphos and Beirut (BYZ638, BYZ702) (Figure 3 and Table 1). It does not match chemically Blackman and Redford’s group 3 (2005), and may potentially correspond to another workshop manufacturing Port Saint Symeon Ware in the region, such as Misis/Mopsuestia (Figure 1b; von Wartburg, 2003).

The study also provided a preliminary glimpse at other types of pottery manufactured by the same workshops. A few samples from Kinet Höyük considered in Blackman and Redford’s study (2005), which are not part of the Port Saint Symeon Ware Family, were also selected for analysis in Lyon. The classification (Figure 3) indicates that examples of various types are included in the two main groups, and may have been traded together with the Port Saint Symeon Ware: monochrome glazed wares with either green or brown glazes (samples LEV962–963, LEV974; Waksman, forthcoming a), ceramics with painted (LEV922), sgraffito (LEV946, LEV961) or relief decoration (LEV921). The latter is part of the “al-Mina?” group,

and finds parallels in the al-Mina material studied by Vorderstrasse (2005: CD-ROM, examples numbers 1937.3-17.11 and 1937.3-17.12 from British Museum; C314D.1937, C314E.1937, C314F.1937 and C314G.1937 from Victoria and Albert Museum). The painted example (LEV922), decorated with “smearred lines”, comes from an earlier twelve century context, which suggests that al-Mina may have exported to Kinet Höyük other types of wares before Port Saint Symeon Ware (Blackman & Redford, 2005). This suggestion may be supported by chemical analysis of imports at nearby Hisn al-Tinat (Waksman, forthcoming b), which corresponds to the occupation of the site during the early/middle Islamic period (Eger, 2010; forthcoming).

These other types also imply that the contribution of the workshops of Port Saint Symeon Ware Family to trade fluxes is probably under-estimated, as the whole pottery repertoire, and especially the usually under-studied plain glazed wares, is not taken into account (see e.g. Waksman, 2018). Further research would be requested to identify the actual repertoire of each of them, and to evaluate which part of it was traded together with the Port Saint Symeon Ware examples.

PRODUCTION TECHNIQUES

The glaze

Table 2 shows that, no matter the production group, glazes covering the Port Saint Symeon Ware samples feature more than 37.3 wt% PbO and less than 2.0 wt% alkaline ($\text{Na}_2\text{O}+\text{K}_2\text{O}$), which classified them as high lead type (Tite et al., 1998; Matin, 2016; Pradell & Molera, 2020). In addition, most of the glazes feature relatively high amounts of calcium with contents between 3.2 to 5.6 wt% CaO for twelve of the seventeen glazes that have been analysed. These high-lead glazes are all transparent, they do not contain opacifiers such as tin oxide, quartz, other mineral particles or even bubbles.

Regarding the colouring agents, copper- (0.4–2.2 wt% CuO) and iron-based (>2.4 wt% FeO) pigments were used to produce the green and yellow glazes, respectively. A manganese-based pigment was used for the underglaze dark purple decoration of one sample from the “al-Mina?” group (LEV919 - dark purple: 0.4 wt% MnO) (Table 2). These results are in accordance with those obtained by Thompson of the Courtauld Institute of Art from the analysis of the pigments of the kiln-wasters discovered at al-Mina (Lane, 1938: 47, note 1).

To verify whether potters applied the high-lead glaze by directly using a lead compound such as galena (PbS) or litharge (PbO), or by processing first a mixture of lead oxide and silica to obtain a frit (Tite et al., 1998; Pradell & Molera, 2020), we used the method which consists of subtracting the contents of lead and colouring oxides from the compositions of the glaze and slip, and then normalizing the compositions again to 100%. The recalculated contents of SiO_2

and CaO of the present study are shown in the binary diagrams of Figures 4b and 4c, respectively. According to Figure 4a, it does not seem that the glazes of Port Saint Symeon Ware samples from both groups were produced from a silica-lead frit since the SiO₂ contents are not much higher in the glazes. It probably consisted in the use of a single lead compound that has been processed beforehand with the same clay mixture as the slip and/or other components, notably Ca-based ones. Figure 4b seems to attest that for a majority of samples there was an addition of a calcium-based component to the glazing mixture, as CaO values are greater in the glazes than in the slips. The surplus of calcium in these glazes cannot therefore be explained by a migration of this element from the slips during the firing. It seems instead that a calcium-rich material has been added to the glaze preparation.

The type of high-lead glaze of the two Port Saint Symeon Ware productions is similar to the ones of two Port Saint Symeon Ware samples discovered in al-Mina, among which one featured a relatively significant CaO content as well (Armstrong et al., 1997: sample 9: CaO = 2.7wt%). Frierman also analysed glazes of “Crusader Ceramics” discovered at ‘Athlit and Caesarea (Israel), some of which seem to correspond to Port Saint Symeon Ware (Frierman, 1967). The chemical compositions obtained also attest to high-lead transparent glazes. In contrast, Frierman detected silver in some of these glazes that he considered as an impurity associated with galena (Frierman, 1967: table 2: AgO = 0.19-1.30wt%). We were unable to quantify silver in the context of the present study. More recently, glaze analyses were carried out on ceramics discovered during surveys in the Osmaniye Province located in the eastern part of Cilicia (Tülek et al., 2020). Samples that the authors relate to the Port Saint Symeon Ware also presented high-lead glazes, with relatively high calcium contents between 2.9 and 6.7 wt% CaO. The latter comparative data should however be taken with caution since the identification of some ceramics as Port Saint Symeon Ware might be questioned according to the pictures of the samples presented in the paper (Tülek et al., 2020). The analysis of these contemporaneous productions shows that the use of a high-lead glaze was a technique commonly used in the region during the late medieval period.

The slip

The slip is a thin coating covering the surface of the ceramic body. It can be applied to the surface of the ceramic body using a brush to produce decoration motifs by contrast of colours with the paste, or as an overall surface (Matin, 2019). Craftspeople use this second method to hide the natural colour of the ceramic body and to provide a smooth, usually white, surface on which they can paint and incise patterns. Although slips are typically made out of clay, we consider that there are two main types of slips: clayey and synthetic ones. The clayey slip can be produced from water-diluted clay which is subsequently dried and sieved, or from a mixture of various constituents, including clay minerals.

We define a synthetic slip in generally the same way as synthetic pastes are described in the literature, where they are also called stonepaste, fritware, artificial paste and siliceous paste. According to the treaty of Abū'l-Qāsim (AD 1301), a member of a Persian potter family from Kashan (Allan, 1973), a synthetic paste generally consists of three main ingredients: 70–80% of powdered quartz, about 10% of frit-glass and 10–20% of fine white clay diluted in water. In this mixture, the quartz powder gives the whiteness to the paste, while the clay is used to bind the materials during its application and will react with the vitreous fragments during the firing to cement the quartz grains together (Mason, 2004). Since synthetic ceramics seemed to first develop in Iraq during the ninth century AD and were subsequently extensively produced throughout the Islamic Near East (Mason, 2004), we consider this technology as reflecting a skillset of Islamic tradition.

Following published studies carried out on Port Saint Symeon Ware exported in the south of France and in Italy, as well as in western Anatolia, in Sardis, the question of Port Saint Symeon Ware's slips being synthetic was raised. First, the slips feature a “pure white colour and a ‘porcelain’ aspect” (translation from Capelli et al., 2005). Second, in these previous studies, the slips were defined as presenting prevalent angular quartz inclusions with a matrix frequently vitrified; the mineral grains showing sometimes rounded rims because of the reaction with the high-lead glaze (Scott & Kamilli, 1981; Capelli & Cabella, 2007). With such description, these slips may be related to the technology of stonepaste (Capelli et al., 2005; 2006; Capelli & Cabella, 2007).

Description of the Port Saint Symeon Ware's slips

The slips of the samples from the “al-Mina?” group feature a clay matrix, often vitrified, that surrounds abundant siliceous inclusions more or less angular (Figure 5d). Some porosities are present as well. Because of the absence of relict glass fragments, this indicates that these slips were probably made from the mix of a small portion of clay with a large quantity of angular siliceous grains, mainly quartz. Following Capelli and Cabella categories, this type of slip falls into the group “Clay-poor, inclusion-rich types: slips with prevailing quartz inclusions” (Capelli & Cabella, 2007), that corresponds to the Port Saint Symeon Ware samples they analysed. Potters from the Kinet regional workshop used a similar type of slip (Figure 5e).

The fluxes contents in the Port Saint Symeon Ware's slips are relatively high, in particular those in PbO and K₂O (Table 2), but it does not correspond to the use of lead-based glass fragments such as those used in the stoneware ceramics production in Turcoman Tabriz, Fatimid Egypt (Tite et al., 2011: table 2) and Ottoman Iznik (Paynter et al., 2004: table 1), for instance. The lead, whose contents are not exceeding 6.0 wt% PbO, probably migrated into the slips of Port Saint Symeon Ware from the glazing mixture during the firing. As for the potassium, it is related to the clay matrix, with a contribution from subordinate inclusions of

K-feldspars mentioned in the description of the Port Saint Symeon Ware's slips discovered in Beirut and in Western Europe (Capelli et al., 2007).

As observed in the previous studies, it is true that these slips have prevalent quartz inclusions with a matrix frequently vitrified, but we cannot consider them as synthetic when we refer to the technical tradition that uses glass fragments, which are lacking in the Port Saint Symeon Ware slips. Instead, we notice high potassium contents (Table 2), with potassium acting as a flux thus favouring the vitrification of the interstitial clay matrix. Potassium-rich clays, which differ from those used for the ceramic bodies (Table 1), may have been chosen on purpose, in the same way that potassium-rich clays were chosen to obtain vitrified surfaces on terra sigillata (Picon, 1997). Because buff-firing calcareous clays poor in potassium were consistently used in the region over time, to manufacture widely-distributed mass-produced wares such as Eastern Sigillata A, Late Roman amphorae LRA1 (e.g. Schneider, 2000; Waksman et al., 2014), and Port Saint Symeon Ware, it is likely that the clays used for the latter's slips were specifically selected for their ability to vitrify at a lower temperature.

To summarize, it seems that the potters of the workshops of Port Saint Symeon Ware we considered mixed a small portion of potassium-rich clay with siliceous grains - perhaps crushed sand or quartz-rich veins or rocks as suggested by the angular forms of the inclusions (Capelli & Cabella, 2007) - rather than worked directly from a clay or a mixture of clays. The technology used for the production of Port Saint Symeon Ware slips could be considered as hybrid, at the interface between clayey and synthetic slips. Thus, the eastern influence, already present in the iconography, also appears in the slip technology.

Comparison with other white slip technologies

When comparing Port Saint Symeon slips with clayey ones from contemporary productions of western Anatolia (Pergamum and Ephesus: Burlot, 2017) and Istanbul (Sirkeci workshop: Burlot et al., forthcoming), a clear difference may be seen. While the latter are characterized by a relatively abundant clayey matrix associated with a low to medium abundance of siliceous inclusions (Figures 5f–5g), the slips of Port Saint Symeon Ware show a much greater abundance of siliceous inclusions with a sparse clayey matrix (Figures 5d–5e).

Closer parallels may be found in the white slips of ceramics manufactured between the late twelfth-seventeenth century at ancient Termez (Molera et al., 2020: figure 5) in Uzbekistan. In fact, according to Mason (2004), the production of quartz-based slips may have been an influence in the development of stonepaste as this technique appeared earlier in several Abbasid centres of the ninth century in Iraq. The application of white slips rich in quartz became a widespread technique used in several Islamic workshops such as in Fustat (Egypt) (Mason, 2004), in Afrasiyab (Uzbekistan) and Nishapur (Iran), where μ -Raman analyses of white slips of samples from both sites revealed quartz as the main component (Holakooei et al., 2019), as

well as in a later Beylik centre in Western Anatolia (Burlot, 2017: figure 8.9d, figure 8.12b, group “Pergame F”).

The use of this type of slip seems to reflect an aesthetic choice rather than a technical one. Quartz-rich slips are indeed whiter than clayey ones, they highlight the colours of the patterns subsequently painted on their surface. However, due to their high contents of silica, these slips have a high thermal expansion coefficient that is not the most suitable to fit the overlying high-lead glaze, whose coefficient is lower (Tite et al., 1998, Pradell & Molera, 2020). Actually, this might explain why potters producing Port Saint Symeon Ware probably added a calcium-based component in the glazing mixture, in order to increase its thermal expansion coefficient and make it more compatible with the quartz-rich slip.

CONCLUSIONS

Thanks to the development of maritime trade led by the Italian maritime Republics in the eastern Mediterranean during the thirteenth century, Port Saint Symeon Ware was a widely distributed ceramic in the medieval period. Several workshops producing this type of polychrome sgraffito in south-eastern Turkey are attested by archaeological evidence. However, chemical analysis of Port Saint Symeon Ware found in Kinet Höyük, and in several harbours across the Mediterranean, supports the idea that there was a main workshop, or group of workshops, which exported both regionally (to the Levant, and to a lesser extent to Cyprus), and long distance (to Italy and southern France). Although further research is requested, it is likely that this workshop was located in al-Mina, the harbour of Antioch. Based on our sampling, there is no evidence that the Port Saint Symeon Ware produced in the area of Kinet Höyük was distributed on a large scale. These data support the viewpoint of Redford, that al-Mina was a major production centre which exported a more expensive Port Saint Symeon Ware of better quality over the longest distances. Smaller regional production centres, like Kinet Höyük, appear to have distributed less elaborated and therefore less expensive products among the local markets (Redford, 2012). Intermediate scales of diffusion may have existed as well, as suggested by clues pointing to another regional workshop.

Although the Port Saint Symeon Ware was produced in several workshops with likely differences in stylistic and iconographic qualities, its dimensions, shapes, and production techniques seem to have been standardized; a phenomenon that, as underlined by Redford, might argue for direct intervention and management by merchants of the Italian maritime Republics (Redford, 2012). However, the arrival of the Mamluks in the region at the end of the thirteenth century would not have stopped the production of this pottery. Following the hypothesis that the production of Port Saint Symeon Ware began in Kinet Höyük after the fall of Antioch to the Mamluks in 1268 (Blackman & Redford 2005), we could suggest that some of the potters working in its harbour, al-Mina, in the early thirteenth century later moved to Kinet and started to produce this type of ceramic with the local clays, using the same decoration

techniques. Meanwhile, some craftsmen stayed in al-Mina to continue producing Port Saint Symeon Ware there. These suggestions would deserve further archaeological and archaeometric investigations.

The decoration techniques of the Port Saint Symeon Ware consisted in the application of a transparent high-lead glaze on a “hybrid” clayey slip whose features suggest technical influences of the Islamic tradition. This slip, characterized by abundant siliceous inclusions of angular shape binded by a very small portion of usually vitrified clay, has some similarities with the technology of stonepaste. It however differs from it by the absence of an added glass (or frit) component, vitrification being obtained instead by the use of potassium-rich clays. The latter were probably selected on purpose, as they do not correspond to the clayey material widely used to manufacture pottery in the area. Potters of the Port Saint Symeon Ware seem to have made specific choices in order to obtain off-white slips, which are visually and technically close to the synthetic ones known from the Islamic world.

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REFERENCES

Allan, J. W., 1973, Abū'l-Qāsim's treatise on ceramics, *Iran*, **11**, 111–20.

Armstrong, P., Hatcher, H., and Tite, M. S., 1997, Changes in Byzantine glazing technology from ninth to thirteenth centuries, in *Acte du VI^{ème} Congrès International sur la Céramique Médiévale en Méditerranée, Aix-en-Provence, 13–18 novembre 1995* (ed. G. Démians d'Archimbaud), 225–29, Narrations, Aix-en-Provence.

Blackman, M. J., and Redford, S., 2005, Neutron activation analysis of medieval ceramics from Kinet, Turkey, especially Port Symeon Ware, *Ancient Near Eastern Studies*, **42**, 83–186.

Burlot, J., 2017, *Premières productions de céramiques turques en Anatolie occidentale : contextualisation et études techniques*, Unpublished Ph.D. thesis, Université Lyon 2, Lyon [in French].

Burlot, J., and Waksman, S. Y., forthcoming, “Port Saint Symeon Ware”: a medieval ware at the crossroads?, in *Excavations at Kinet Höyük: The Medieval Period* (ed. S. Redford).

Burlot, J., Waksman, S. Y., Ricci, A., and Wohmann, R., forthcoming, Integrating archaeological and archaeometric data: examining late Byzantine pottery from Küçükyalı (Istanbul), in *Proceedings of the 12th International Congress AIECM3 on Medieval and Modern Period Mediterranean, Athens, 21–27 October 2018* (eds. P. Petridis, A.G. Yangaki, N. Liaros, and E.-E. Bia).

Capelli, C., and Cabella, R., 2007, The archaeometric study of white slips: a contribution to the characterization of the medieval Mediterranean productions, in *Archaeometric and archaeological approaches to ceramics: papers presented at EMAC '05, 8th European Meeting on Ancient Ceramics, Lyon, 2005* (ed. S. Y. Waksman), 155–59, BAR **S1691**, Archaeopress, Oxford.

Capelli, C., Cabella, R., Riccardi, M. P., and Waksman, S. Y., 2005, Caratterizzazione archeometrica di ceramiche graffite medievali (*Port Saint Symeon Ware*) rinvenute a Beirute, Genova e Marsiglia, in *Atti del III Congresso Nazionale di Archeometria, Bressanone, febbraio 2004* (ed. C. D'Amico), 193–202, Pàtron Editore, Bologna [in Italian].

Capelli, C., Richarté, C, Vallauri, L., Waksman, Y., and Gavagnin S., 2006, Ceramiche del gruppo *Port Saint Symeon Ware* rinvenute a Genova, Marsiglia e Beirut: dati archeologici ed archeometrici, in *Genova e Savona, la Liguria crocevia della ceramica : atti XXXVII Convegno Internazionale della ceramica, Savona, 28–29 maggio 2004*, 81–88, Centro Ligure per la Storia della Ceramica, Albisola, All’Insegna del Giglio, Florence [in Italian].

Capelli, C., Cabella, R., and Waksman, S. Y., 2007, Archaeometric investigation on 13th century glazed and slipped pottery found in Liguria and Provence, in *Archaeometric and archaeological approaches to ceramics: papers presented at EMAC ‘05, 8th European Meeting on Ancient Ceramics, Lyon, 2005* (ed. S. Y. Waksman), 149–54, BAR **S1691**, Archaeopress, Oxford.

Eger, A. A., 2008, *The Islamic-Byzantine frontier: interaction and exchange among Muslim and Christian communities*, Unpublished Ph.D. thesis, University of Chicago, Chicago.

Eger, A. A., 2010, Hisn al-Tinat on the Islamic-Byzantine frontier: synthesis and the 2005–2008 survey and excavation on the Cilician plain (Turkey), *Bulletin of the American School of Oriental Research*, **357**, 49–76.

Eger, A. A., forthcoming, *Excavations at Tüpraş field and surrounding surveys: the Roman, Byzantine, and early medieval periods*, Kinet Höyük Excavations, **8**.

Frierman, J. D., 1967, The physical and chemical properties of some Crusader ceramics, *Israel Exploration Journal*, **17(3)**, 153–57.

General Directorate of Mineral Research and Exploration, 2002a. *Geological map of Turkey: Adana sheet*, 1:500,000, MTA, Ankara.

General Directorate of Mineral Research and Exploration, 2002b. *Geological map of Turkey: Hatay sheet*, 1:500,000, MTA, Ankara.

Haldon, J., 2010, *The Palgrave atlas of Byzantine history*, Palgrave Macmillan, Basingstoke.

Hild, F., and Hellenkemper, H., 1990, *Kilikien und Isaurien*, Tabula Imperii Byzantini 5, Verlag der Österreichischen Akademie der Wissenschaften, Wien [in German].

Holakooei, P., de Lapérouse, J.-F., Carò, F., Röhrs, S., Franke, U., Müller-Wiener, M., and Reiche, I., 2019, Non-invasive scientific studies on the provenance and technology of early Islamic ceramics from Afrasiyab and Nishapur, *Journal of Archaeological Science: Reports*, **24**, 759–72.

Jacoby, D., 2004, Society, culture, and the arts in Crusader Acre, in *France and the Holy Land: Frankish culture at the end of the Crusades* (ed. D. H. Weiss and L. Mahoney), 97–137, Johns Hopkins University Press, Baltimore.

Karadima, C., Matsas, D., Blondé, F., and Picon, M., 2002, Workshop references and clay surveying in Samothrace: an application to the study of the origin of some ceramic groups, in *Modern trends in scientific studies on ancient ceramics, Papers presented at the 5th European Meeting on Ancient Ceramics, Athens, 1999* (eds. V. Kilikoglou, A. Hein and Y. Maniatis), 157–62, Archaeopress, Oxford.

Lane, A., 1938, Medieval finds at Al Mina in north Syria, *Archaeologia*, **87**, 19–78.

Mason, R. B., 2004, *Shine like the sun : lustre-painted and associated pottery from the medieval Middle East*, Bibliotheca Iranica, Islamic Art and Architecture Series **12**, Mazda, Royal Ontario Museum, Costa Mesa.

Matin, M., 2016, *Revisiting the origins of Islamic glazed pottery: a technological examination of 8th-10th century AD ceramics from Islamic lands*, Unpublished Ph.D. thesis, University of Oxford, Oxford.

Matin, M., 2019, Glazes, Slips, and Paints, in *The Encyclopedia of Archaeological Sciences* (ed. S. López-Varela), Vol. **2**, Wiley Blackwell, Chichester, Malden.

Molera, J., Martínez Ferreras, V., Fusaro, A., Gurt Esparraguera, J. M., Gaudenzi, M., Pidaev, S. R., and Pradell, T., 2020, Islamic glazed wares from ancient Termez (southern Uzbekistan). Raw materials and techniques, *Journal of Archaeological Science: Reports*, **29**, 102169.

Paynter, S., Okyar, F., Wolf, S., and Tite, M. S., 2004, The production technology of Iznik pottery – a reassessment, *Archaeometry*, **46(3)**, 421–37.

Picon, M., 1984, Le traitement des données d'analyse, in *Datation-caractérisation des céramiques anciennes* (eds. T. Hackens and M. Schvoerer), 379–99, PACT **10**, Presses du CNRS, Paris, Centre universitaire européen pour les biens culturels, Ravello [in French].

Picon, M., 1997, Les argiles des vernis rouges et jaunes des céramiques sigillées de La Graufesenque (Aveyron), et la céladonite utilisée comme pigment vert dans les peintures murales romaines, *Revue d'Archéométrie*, **21**, 89–96 [in French].

Pradell, T., and Molera, J., 2020, Ceramic technology. How to characterise ceramic glazes, *Archaeological and Anthropological Sciences*, **12**, 189.

Redford, S., 2012, Trade and economy in Antioch and Cilicia in the twelfth and thirteenth centuries, in *Trade and markets in Byzantium* (ed. C. Morrisson), 297–309, Dumbarton Oaks, Washington.

Schneider, G., 2000, Chemical and mineralogical studies of Late Hellenistic to Byzantine pottery production in the eastern Mediterranean, *Rei Cretariae Romanae Fautorum Acta*, **36**, 525–536.

Scott, J., and Kamilli, D., 1981, Late Byzantine glazed pottery from Sardis, in *Actes du XV^e Congrès international d'études byzantines, Athènes, 1976*, 679–96, Vol. **II.2**, Association Internationale des Études Byzantines, Athens.

Stern, E. J., 1997, Excavation of the courthouse site at 'Akko: the pottery of the Crusader and Ottoman periods, *Atiqot*, **31**, 33–70.

Stern, E. J., 2010, Ceramics as a reflection of maritime commercial activity at Crusader Acre, in *One thousand nights and days. 'Akko through the ages* (eds. A. E. Killebrew and V. Raz-Romeo), 55–59, Hecht Museum, Haifa.

Stern, E. J., 2012, *Akko I: the 1991–1998 excavations: the Crusader-period pottery. Part I*, IAA Reports **51**, Israel Antiquities Authority, Jerusalem.

Tite, M. S., Freestone, I. C., Mason, R. B., Molera, J., Vendrell-Saz, M., and Wood, N., 1998, Lead glazes in Antiquity: methods of production and reasons for use, *Archaeometry*, **40(2)**, 241–60.

Tite, M. S., Wolf, S., and Mason, R. B., 2011, The technological development of stonepaste ceramics from the Islamic Middle East, *Journal of Archaeological Science*, **38(3)**, 570–80.

Tülek, F., Çelik, G. A., Atapek, Ş. H., and Polat, Ş., 2020, Characterization of medieval glazed ceramics of the east plain Cilicia survey, *Journal of Archaeological Science: Reports*, **29**.

Vorderstrasse, T., 2005, *Al-Mina: a port of Antioch from late antiquity to the end of the Ottomans*. Nederlands Instituut voor het Nabije Oosten, Leiden.

Waagé, F. O., 1948, The glazed pottery, in *Antioch-on-the-Orontes, IV, part one: ceramics and Islamic coins* (ed. F. O. Waagé), 79–108, Princeton University Press, Princeton.

Waksman, S. Y., 2014, Archaeometric approaches to ceramics production and imports in medieval Cyprus, in *Cypriot medieval ceramics: reconsiderations and new perspectives* (eds. D. Papanikola-Bakirtzi and N. Coureas), 257–77, Cyprus Research Centre, A. G. Leventis Foundation, Nicosia.

Waksman, S. Y., 2017, “Provenance studies”: productions and compositional groups, in *Oxford Handbook of Archaeological Ceramic Analysis* (ed. A. Hunt), 148–161, Oxford University Press, Oxford.

Waksman, S. Y., 2018, Defining the main “Middle Byzantine Production” (MBP): changing perspectives in Byzantine pottery studies, in *XIth Congress AIECM3 on Medieval and Modern Period Mediterranean Ceramics Proceedings (19–24 October 2015 Antalya), Vol. 1* (ed. F. Yenişehirlioğlu), 397–408, Koç University VEKAM, Ankara.

Waksman, S. Y., forthcoming a, Provenance studies of Byzantine and Levantine pottery imported at medieval Kinet Höyük, Turkey (12th-14th c.), in *Excavations at Kinet Höyük: The Medieval Period* (ed. S. Redford).

Waksman, S. Y., forthcoming b, Archaeometric investigations of early Islamic pottery excavated at Hişn al-Tīnāt (Turkey), in *Excavations at Tüpraş field and surrounding surveys: the Roman, Byzantine, and early medieval periods* (ed. A.A. Eger), Kinet Höyük Excavations, **8**.

Waksman, S.Y., Morozova, Y., Zelenko, S., and Çolak M., 2014, Archaeological and archaeometric investigations of the amphorae cargo of a late Roman shipwreck sunk near the Cape of Plaka (Crimea, Ukraine), in *LRCW4, Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean: Archaeology and Archaeometry*, 911–29, BAR International Series **2616(I)**, Archaeopress, Oxford.

Wartburg (von), M.-L., 2003, Cypriot contacts with East and West as reflected in medieval glazed pottery from the Paphos region, in *Actes du VII^e Congrès international sur la céramique médiévale en Méditerranée, Thessaloniki, 11–16 octobre 1999* (ed. C. Bakirtzis), 153–66, Caisse des Recettes Archéologiques, Athens.

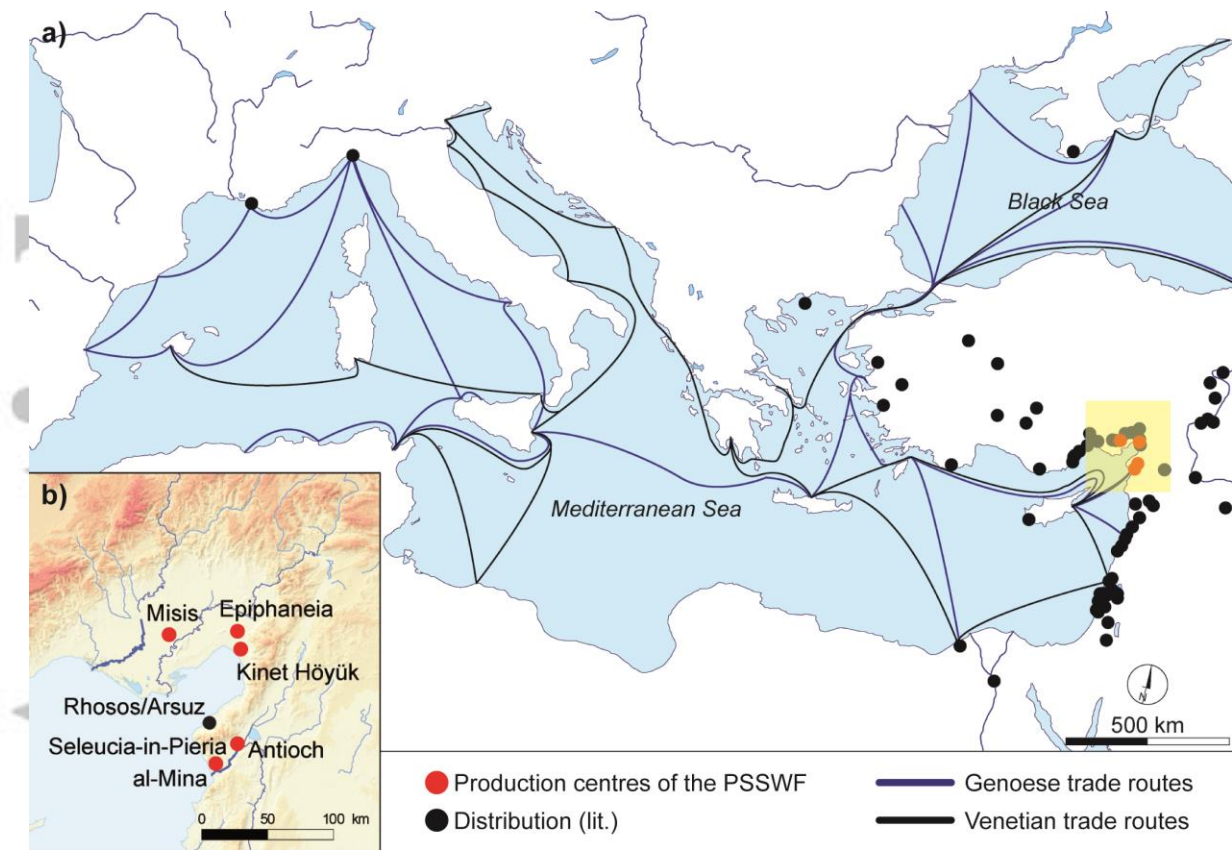


FIGURE 1 Maps showing: (a) the distribution of the Port Saint Symeon Ware Family (PSSWF), according to the literature (Burlot & Waksman, forthcoming, notes 1 and 2, trade routes according to Haldon, 2010: 151, map 11.5) (CAD: J. Burlot); (b) the sites mentioned in the area of Kinet Höyük (base map O. Barge, map S.Y. Waksman).

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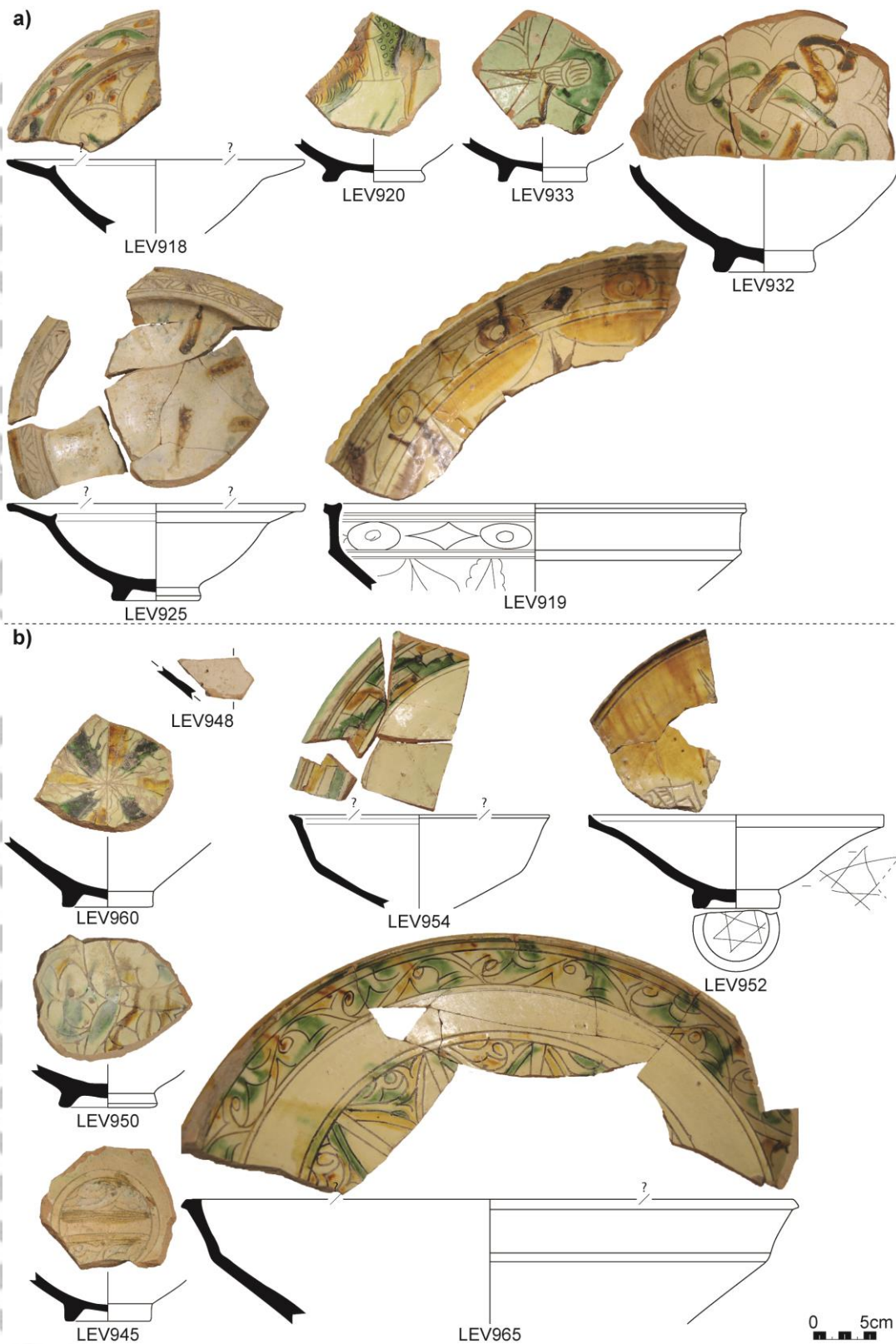


FIGURE 2 Examples of Port Saint Symeon Wares found in Kinet Höyük analyzed: (a) samples from “al-Mina?” production; (b) samples from “Kinet region” production (Lyon laboratory ids. are indicated; Pictures: S.Y. Waksman; Drawings from Blackman and Redford (2005); CAD: J. Burlot).

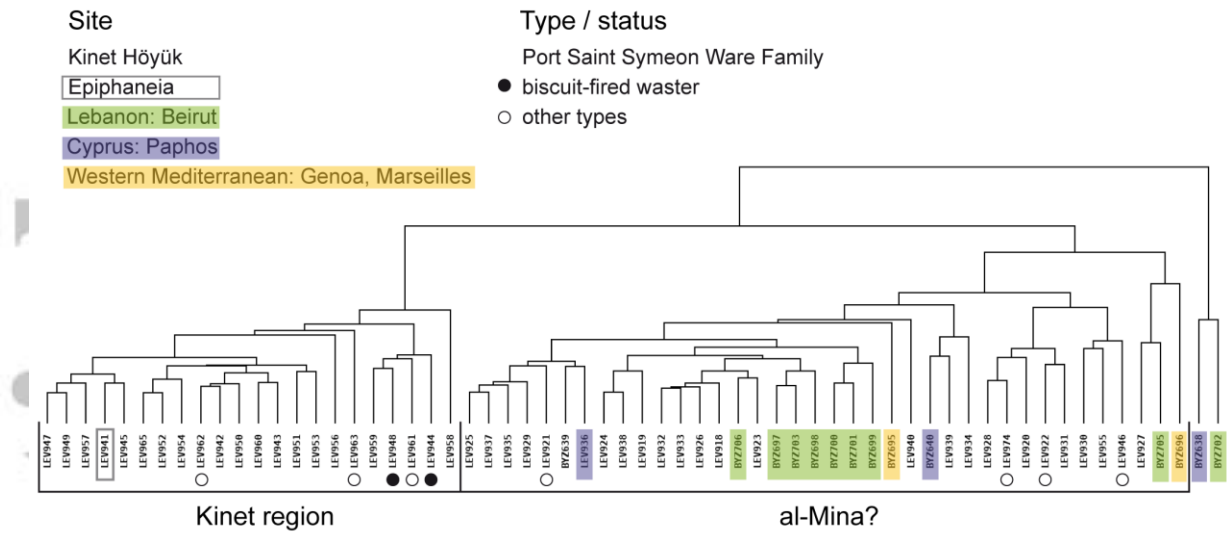


FIGURE 3 Hierarchical clustering analysis based on the chemical composition of the ceramics body (15 elements, see Table 1), of samples from Kinet Höyük together with examples of Port Saint Symeon Wares found in Mediterranean harbours. The main chemical groups are underlined, colours are according to sites and symbols to type or status as local reference (S.Y. Waksman).

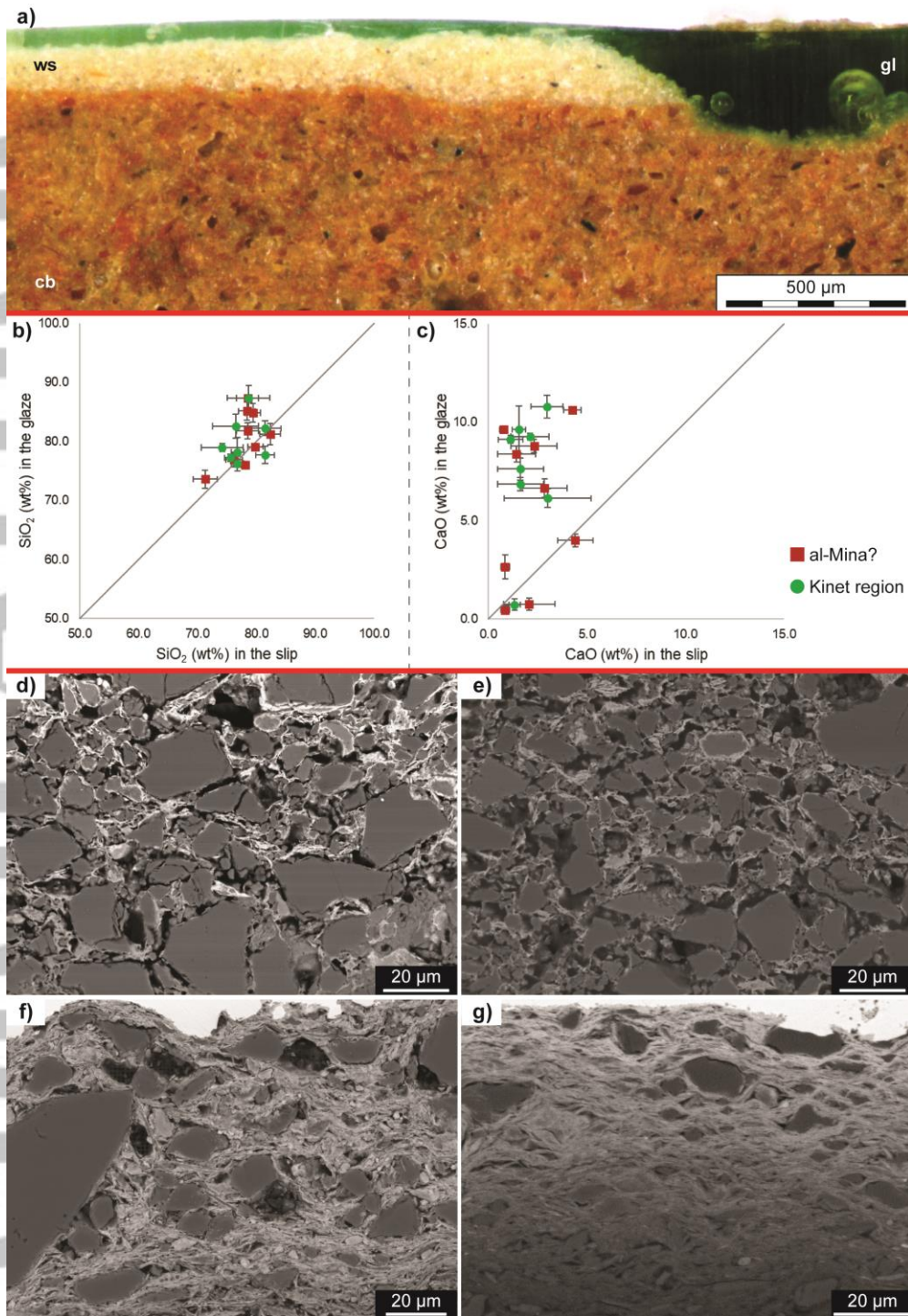


FIGURE 4 (a) Cross-section of an example of Port Saint Symeon Ware (LEV927 - green glazed, “al-Mina?” production) (gl: glaze; ws: white slip; cb: ceramic body); (b-c) Binary diagrams showing: (b) SiO₂ contents in the glaze (renormalized without lead and colouring oxides) vs. SiO₂ contents in the slip (renormalized without lead oxide); (c) CaO contents in the glaze (renormalized without lead and colouring oxides) vs. CaO contents in the slip (renormalized without lead oxide); (d-g) BSE images of cross sections of clayey slips representative of the types discussed in the text: (d) sample LEV933 (“al-Mina?”); (e) sample LEV950 (“Kinet region”); (f) sample BZY293 (“Ephesus local c4”, in Burlot 2017); (g) sample BZY588 “Sirkeci S2”, in Burlot et al., forthcoming) (J. Burlot).

TABLE 1 Chemical compositions of the ceramics body, the samples are ranked as in the classification Figure 3 (major and minor elements in oxide weight %, trace elements in ppm; m: mean, σ : standard deviation; elements between brackets were not used in the classification, data marked with an asterisk were not taken into account in the calculation of m and σ).

Lab. id.	CaO	Fe ₂ O ₃	TiO ₂	K ₂ O	SiO ₂	Al ₂ O ₃	MgO	MnO	(Na ₂ O)	(P ₂ O ₅)	Zr	(Sr)	Rb	Zn	Cr	Ni	(Ba)	V	Ce
Kinet region																			
LEV947	19.41	7.08	0.630	1.21	49.06	10.87	10.34	0.139	0.75	0.19	118	400	45	70	719	716	384	89	39
LEV949	18.94	7.05	0.635	1.20	49.51	10.96	10.22	0.135	0.73	0.22	111	378	39	72	697	739	383	90	39
LEV957	17.83	7.26	0.615	1.17	49.41	10.68	11.63	0.135	0.72	0.21	108	351	41	70	777	799	392	85	43
LEV941	16.41	7.15	0.632	1.24	49.67	10.87	12.46	0.137	0.68	0.47	120	387	46	76	693	724	318	97	40
LEV945	17.77	7.33	0.616	1.27	49.47	10.85	11.31	0.149	0.64	0.30	109	392	45	73	709	790	377	97	41
LEV965	17.35	7.17	0.638	1.27	49.93	10.90	11.37	0.137	0.73	0.19	119	367	47	70	759	746	384	80	51
LEV952	17.48	7.20	0.652	1.38	50.35	11.28	10.20	0.141	0.78	0.19	117	371	49	71	723	726	359	85	48
LEV954	18.38	7.28	0.639	1.20	49.30	11.02	10.85	0.141	0.68	0.22	113	374	52	72	724	752	385	90	45
LEV962	15.40	7.68	0.645	1.20	50.63	11.14	11.99	0.141	0.62	0.26	113	357	54	74	793	813	373	92	42
LEV942	15.63	7.38	0.647	1.25	50.73	11.20	11.75	0.141	0.72	0.26	113	360	51	77	739	750	322	89	48
LEV950	15.54	7.61	0.634	1.18	50.24	10.89	12.50	0.139	0.66	0.23	111	341	47	73	863	853	376	91	48
LEV960	16.88	7.11	0.648	1.30	51.00	11.10	10.53	0.138	0.79	0.20	114	399	50	78	726	694	363	102	46
LEV943	15.68	7.13	0.633	1.23	51.32	10.90	11.57	0.1360	0.78	0.32	116	410	49	71	727	733	364	93	44
LEV951	16.90	7.75	0.647	1.27	49.50	11.58	11.18	0.137	0.53	0.22	112	367	52	79	680	784	373	91	42
LEV953	17.36	7.61	0.663	1.29	49.90	11.59	10.27	0.141	0.64	0.21	115	376	49	75	699	739	356	100	51
LEV956	15.10	7.27	0.643	1.25	51.05	11.17	11.79	0.1420	0.72	0.22	111	304	*29	71	801	768	359	96	44
LEV963	17.59	7.89	0.664	1.17	48.76	11.28	10.89	0.123	1.14	0.21	98	317	41	76	617	775	278	111	42
LEV959	14.44	7.65	0.615	1.15	50.77	10.64	13.38	0.142	0.72	0.20	104	314	46	71	*975	887	357	88	40
LEV948	16.36	7.61	0.566	1.05	49.98	10.05	13.15	0.139	0.54	0.24	99	364	48	78	884	*962	312	93	41
LEV961	12.85	8.16	0.586	1.21	51.02	10.51	14.05	0.146	0.62	0.52	98	332	45	77	848	*1034	372	96	44
LEV944	14.78	7.78	0.539	0.98	51.00	9.81	13.83	0.138	0.55	0.26	91	363	44	78	*956	*1034	352	96	32
LEV958	13.20	7.94	0.706	1.34	52.26	11.96	11.11	0.15	0.76	0.24	123	360	56	78	769	801	421	94	47
m	16.42	7.46	0.632	1.22	50.22	10.97	11.65	0.139	0.70	0.25	111	363	47	74	747	768	362	93	44
σ	1.72	0.32	0.03	0.09	0.87	0.47	1.16	0.005	0.12	0.09	8	28	4	3	66	48	31	7	4
al-Mina?																			
LEV925	22.23	6.64	0.709	1.75	48.91	12.64	5.03	0.158	1.40	0.23	124	413	50	88	369	237	374	98	48
LEV937	21.49	6.78	0.701	1.65	49.53	12.51	5.45	0.152	1.24	0.27	123	485	55	90	351	234	357	101	47
LEV935	21.62	6.53	0.697	1.93	49.42	12.35	5.38	0.158	1.38	0.26	120	478	56	85	367	240	403	97	51
LEV929	21.31	6.65	0.704	1.79	49.60	12.59	5.20	0.158	1.44	0.29	126	459	58	87	390	226	392	111	50
LEV921	21.14	6.59	0.693	1.93	50.29	12.27	5.15	0.139	1.21	0.29	139	410	58	89	315	229	357	103	48
BYZ639	22.17	6.58	0.671	1.88	49.57	12.15	4.83	0.159	1.53	0.23	122	525	48	85	365	177	380	118	45
LEV936	20.06	6.90	0.740	1.91	50.07	12.89	5.14	0.164	1.43	0.30	124	434	48	85	378	234	400	111	48
LEV924	17.47	7.09	0.730	1.98	51.91	13.30	5.70	0.153	1.18	0.24	133	422	67	95	314	253	410	109	52
LEV938	17.12	7.13	0.743	1.99	51.83	13.29	5.89	0.147	1.25	0.39	146	411	68	93	329	258	397	104	51
LEV919	17.63	6.82	0.746	1.85	52.39	13.19	5.26	0.162	1.38	0.27	146	394	61	88	382	243	394	108	49
LEV932	19.52	6.69	0.714	1.84	51.00	12.71	5.35	0.1650	1.50	0.25	127	417	56	87	386	244	433	104	46
LEV933	19.44	6.77	0.715	1.84	51.13	12.72	5.30	0.1630	1.36	0.33	136	453	63	86	358	236	489	104	50
LEV926	19.70	6.77	0.717	1.78	50.74	12.84	5.19	0.158	1.56	0.25	124	461	58	86	372	231	375	98	53
LEV918	20.13	6.82	0.716	1.78	50.47	12.69	5.41	0.156	1.35	0.25	135	437	62	89	356	235	379	96	46
BYZ706	19.16	7.00	0.720	2.19	50.89	12.90	4.98	0.157	1.39	0.40	124	424	62	96	345	192	462	95	52
LEV923	19.30	6.87	0.726	1.83	51.02	12.92	5.20	0.16	1.46	0.26	131	420	63	92	384	241	432	104	56
BYZ697	19.14	7.27	0.730	2.21	50.74	12.89	4.91	0.168	1.26	0.43	125	389	60	89	347	195	567	112	58
BYZ703	18.46	7.14	0.729	2.17	51.05	13.10	4.99	0.163	1.41	0.48	128	391	62	97	366	197	*699	112	59
BYZ698	18.81	7.12	0.727	2.21	51.02	13.01	4.96	0.158	1.36	0.38	127	379	62	85	358	197	*606	113	50
BYZ700	20.71	6.86	0.700	2.17	49.94	12.57	5.01	0.157	1.34	0.31	127	422	58	88	342	187	492	105	61
BYZ701	20.21	6.76	0.699	1.99	50.93	12.63	4.74	0.1650	1.38	0.29	124	407	59	84	420	176	483	100	60
BYZ699	20.81	6.78	0.701	2.05	50.22	12.47	4.79	0.176	1.48	0.25	123	405	55	81	367	182	*583	120	56
BYZ695	17.43	7.00	0.711	2.42	52.07	12.91	5.40	0.15	1.20	0.43	145	431	64	86	308	194	354	119	61
LEV940	16.87	6.92	0.740	1.51	52.95	13.17	6.07	0.162	1.14	0.25	131	329	48	94	358	255	461	112	49
BYZ640	19.23	8.04	0.761	1.83	48.60	13.17	6.59	0.1410	1.22	0.20	137	351	62	89	407	295	365	124	54
LEV939	17.39	7.58	0.786	1.72	50.58	13.55	6.55	0.139	1.20	0.27	140	333	64	89	481	344	362	118	54
LEV934	15.82	7.72	0.820	2.06	50.55	14.15	6.63	0.144	1.60	0.25	134	374	65	95	360	271	340	126	43

LEV928	22.62	6.72	0.712	1.53	48.67	12.06	5.92	0.118	1.19	0.23	142	372	60	78	487	286	335	106	49
LEV974	23.42	6.51	0.694	1.56	48.16	12.15	5.70	0.12	1.01	0.44	143	415	69	80	393	248	369	109	48
LEV920	23.75	6.40	0.672	1.59	48.45	11.66	5.89	0.125	0.95	0.27	141	400	58	78	438	321	419	97	59
LEV922	20.65	6.49	0.688	1.47	48.83	11.99	8.55	0.1200	0.75	0.24	138	351	50	81	371	258	317	107	51
LEV931	20.82	6.69	0.715	1.54	49.56	12.16	6.61	0.1220	1.14	0.28	149	391	49	77	480	288	333	93	51
LEV930	19.17	7.30	0.753	1.64	49.14	13.26	6.75	0.1300	1.16	0.26	125	381	49	84	421	330	326	118	53
LEV955	18.25	7.31	0.782	1.39	50.00	12.96	7.11	0.118	1.57	0.28	111	356	46	80	514	400	302	116	41
LEV946	20.07	7.41	0.765	1.38	48.69	12.31	7.44	0.145	1.25	0.29	121	380	52	77	538	*515	367	100	45
LEV927	13.61	7.83	0.844	2.08	52.31	14.50	6.32	0.1390	1.81	0.22	160	354	62	89	373	265	361	120	58
BYZ705	13.98	8.08	0.827	2.23	51.40	14.40	6.65	0.134	1.50	0.38	156	376	64	87	341	236	378	151	61
BYZ696	16.19	7.08	0.761	2.20	52.75	13.66	4.83	0.107	1.49	0.64	135	*582	65	87	406	186	398	99	66
m	19.39	6.99	0.731	1.87	50.40	12.86	5.71	0.148	1.33	0.30	133	406	58	87	385	244	393	109	52
σ	2.34	0.42	0.040	0.26	1.26	0.63	0.86	0.017	0.20	0.09	11	43	6	5	54	50	57	11	6
BYZ638	24.54	5.25	0.558	2.29	51.03	10.91	3.71	0.086	1.17	0.22	178	534	67	67	338	134	454	69	56
BYZ702	23.44	5.80	0.583	2.21	48.99	11.61	5.89	0.088	0.84	0.27	156	418	69	69	344	165	583	81	69

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TABLE 2 Semi-quantitative SEM-EDS analysis of the glazes and slips, in wt%. Samples are presented by production (-: below detection limits; m: mean; σ : standard deviation; data marked with an asterisk were not taken into account in the calculation of m and σ).

Lab. id.	Surface	Decoration - Colour of the area analysed	wt%											
			SiO ₂	PbO	Na ₂ O	K ₂ O	CaO	Al ₂ O ₃	MgO	FeO	CuO	MnO	ZnO	TiO ₂
Glazes														
Kinet region														
LEV945	in.	painted dec. - light green	29.7	60.7	-	-	3.6	3.3	0.7	0.3	0.5	-	0.8	-
LEV950	in.	painted dec. - light green	35.6	51.2	0.5	0.7	4.2	3.8	1.0	0.6	1.1	-	0.7	-
LEV951	in.	painted dec. - light green	38.5	52.8	-	0.6	*0.3	3.7	0.7	0.7	0.5	-	0.8	-
LEV952	in.	painted dec. - yellow	37.4	49.4	-	0.6	4.2	3.1	-	3.4	0.6	-	0.7	-
LEV954	out.	monochrome - green	42.7	44.8	-	0.6	3.2	4.4	0.7	0.3	2.3	-	0.6	-
LEV960	in.	painted dec. - light green	34.9	52.5	-	0.7	4.9	3.7	0.9	0.3	1.0	-	0.6	-
LEV965	in.	painted dec. - colourless	42.3	43.5	0.4	1.1	4.1	5.3	0.9	0.5	0.7	-	0.9	-
	out.	monochrome - yellow	45.8	37.3	0.5	1.4	3.3	6.9	0.8	3.3	0.3	-	0.3	-
m			38.4	49.0	0.2	0.7	3.9	4.3	0.7	1.2	0.9	-	0.7	-
σ			5.1	7.1	0.2	0.4	0.6	1.3	0.3	1.3	0.6	-	0.2	-
al-Mina?														
LEV918	in.	painted dec. - orange	31.9	45.2	0.4	1.3	3.8	5.4	0.6	9.9	0.3	-	0.4	-
LEV919	in.	painted dec. - purple-brown	40.5	46.0	-	0.8	5.6	4.7	1.0	-	0.3	0.4	0.3	-
LEV920	in.	painted dec. - colourless	33.4	53.2	0.6	0.8	4.2	3.8	1.2	0.6	0.7	-	0.5	-
LEV925	in.	painted dec. - light yellow	43.2	47.2	0.6	0.9	2.0	3.1	1.1	0.7	0.3	-	0.6	-
LEV927	in.	painted dec. - light green	37.7	55.4	0.3	1.0	-	3.8	-	0.5	1.0	-	-	-
	in.	painted dec. - green	33.8	53.0	0.6	1.1	1.1	4.1	0.7	1.3	2.2	-	1.5	-
LEV932	in.	painted dec. - colourless	40.1	49.7	0.3	0.6	3.3	4.3	0.7	-	0.3	-	-	-
LEV933	in.	painted dec. - light green	34.5	55.9	0.4	0.6	3.7	3.7	0.8	-	0.4	-	-	-
LEV934	in.	painted dec. - yellow	33.0	57.1	0.6	0.4	-	3.2	0.8	2.4	0.4	-	1.2	-
m			36.5	51.4	0.5	0.8	3.4	4.0	0.9	2.6	0.6	-	0.8	-
σ			4.0	4.5	0.1	0.3	1.5	0.7	0.2	3.7	0.6	-	0.5	-

Slips													
Kinet region													
LEV945	in.	70.4	2.6	0.4	5.6	1.5	15.6	1.4	1.0	-	-	-	1.2
LEV948	in.	71.0	-	0.9	5.2	1.2	16.1	2.4	1.5	-	-	-	0.9
LEV950	in.	75.8	5.2	1.1	4.2	1.1	9.5	1.3	0.5	-	-	-	0.4
LEV951	in.	75.1	2.6	0.4	4.9	1.3	12.6	1.2	1.1	-	-	-	0.7
LEV952	in.	78.2	2.1	-	5.2	2.0	9.1	1.2	1.2	-	-	-	0.5
LEV954	in.	69.9	5.8	0.4	4.6	2.8	12.0	1.7	1.4	0.4	-	-	0.9
LEV960	in.	73.4	0.8	0.7	4.3	2.9	13.9	1.9	0.9	-	-	-	0.7
LEV965	in.	73.4	2.1	1.1	4.7	1.6	13.1	1.8	0.9	-	-	-	0.7
m		73.4	2.7	0.7	4.8	1.8	12.7	1.6	1.1	-	-	-	0.8
σ		2.9	2.0	0.3	0.5	0.7	2.6	0.4	0.3	-	-	-	0.2
al-Mina?													
LEV918	in.	67.7	1.6	0.9	7.8	2.2	15.1	1.2	1.2	0.5	0.3	-	0.5
LEV919	in.	72.1	3.6	0.9	4.8	4.0	10.6	2.1	1.1	-	-	-	0.4
LEV920	in.	76.0	1.1	0.9	4.4	0.8	13.7	1.6	0.7	-	-	-	0.6
LEV925	in.	75.6	3.0	0.7	5.0	4.2	8.2	1.4	1.2	0.3	-	-	-
LEV927	in.	73.6	4.2	1.0	5.9	0.8	10.9	1.6	1.0	-	-	-	0.5
LEV932	in.	77.1	5.0	0.7	3.0	2.7	8.6	1.5	0.8	-	-	-	0.3
LEV933	in.	74.7	5.0	1.2	4.3	1.3	10.7	1.4	0.5	-	-	-	-
LEV934	in.	72.7	5.4	1.1	4.6	1.9	10.9	1.5	1.0	-	-	-	0.5
m		73.7	3.6	0.9	5.0	2.2	11.1	1.5	1.0	-	-	-	0.4
σ		2.9	1.6	0.2	1.4	1.3	2.3	0.3	0.2	-	-	-	0.2