



# Long-term pottery production and chemical reference groups: examples from Medieval Western Turkey

S.Y. Waksman

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LATE HELLENISTIC  
TO MEDIAEVAL FINE WARES  
OF THE AEGEAN COAST OF ANATOLIA

PRACE INSTYTUTU KULTUR ŚRÓDZIEMNOMORSKICH I ORIENTALNYCH  
POLSKIEJ AKADEMII NAUK

TOM 1

CERAMIKA STOŁOWA  
EGEJSKIEGO WYBRZEŻA ANATOLII  
OD OKRESU PÓŹNOHELLENISTYCZNEGO  
DO ŚREDNIOWIECZA

PRODUKCJA, NAŚLADOWNICTWA I ZASTOSOWANIE

pod redakcją  
HENRYKA MEYZA

przy współpracy  
KRZYSZTOFA DOMŻALSKIEGO

WYDAWNICTWO NERITON



Warszawa 2014

TRAVAUX DE L'INSTITUT DES CULTURES MÉDITERRANÉENNES ET ORIENTALES  
DE L'ACADEMIE POLONAISE DES SCIENCES

TOME 1

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TO MEDIAEVAL FINE WARES  
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THEIR PRODUCTION, IMITATION AND USE

édité par

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avec la collaboration de

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ÉDITIONS NERITON



Varsovie 2014

# Contents

|                        |   |
|------------------------|---|
| Introduction . . . . . | 7 |
|------------------------|---|

## PART I: Production at Pergamon and its region

|   |    |
|---|----|
| <i>Sigillata of Pergamon – Eastern Sigillata C. Problems of classification and chronology</i><br>– by S. Japp, Deutsches Archäologisches Institut, Berlin . . . . .   | 11 |
| <i>La production des ateliers de céramique de Pergame (Vallée de Ketios) : un aperçu général</i><br>– by O. Bounegru, Catedra de Istorie Veche și Arheologie Facultatea de Istorie,<br>Universitatea „Al. I. Cuza” Iași . . . . .   | 23 |
| <i>Statistical interpretation of elemental concentration data and the origin of Pergamene pottery</i><br>– by H. Mommsen, Helmholtz-Institut für Strahlen- und Kernphysik, Rheinische Friedrich-Wilhelms-Universität Bonn & S. Japp, Deutsches Archäologisches Institut, Berlin . . . . . | 31 |
| <i>A Pergamene (?) modiolus in the National Museum of Denmark</i><br>– by J. Lund, Antiksamlingen, Nationalmuseet, København . . . . .  | 41 |

## PART II: Other production sites of western Anatolia

|  |     |
|--|-----|
| <i>Ephesus – local vs import: The Early Byzantine fine ware</i><br>– by A. Waldner, Institut für Kulturgeschichte der Antike, Österreichische Akademie der Wissenschaften & S. Ladstätter, Österreichisches Archäologisches Institut, Wien . . . . .       | 49  |
| <i>Microstructural characteristics of appliqué wares from Ephesus</i><br>– by L. Peloschek, Österreichisches Archäologisches Institut, Wien & A. Laetzer-Lasar, Internationales Kolleg Morphomata, Universität zu Köln . . . . .                           | 59  |
| <i>Aspects of fine ware consumption in Aeolic Kyme (I-VI AD)</i><br>– by V. Di Giovanni, Missione Archeologica Italiana a Kyme Eolica, Università degli Studi di Napoli Federico II . . . . .  | 71  |
| <i>From Hellenistic to Roman Imperial in Pisidian tableware: the genesis of Sagalassos Red Slip Ware</i><br>– by M. Van der Enden, University of Leicester, J. Poblome, Katholieke Universiteit Leuven & Ph. Bes, Katholieke Universiteit Leuven . . . . . | 81  |
| <i>Zur Neuentdeckung eines Töpfereizentrums der Cypriot Red Slip Ware/Late Roman D Ware im südlichen Pisidien</i><br>– by M. Zelle, Lippisches Landesmuseum, Detmold . . . . .   | 95  |
| <i>Long-term pottery production and chemical reference groups: examples from Medieval Western Turkey</i><br>– by S.Y. Waksman, Laboratoire de Archéométrie et Archéologie, CNRS UMR 5138, Maison de l’Orient et de la Méditerranée, Lyon. . . . .          | 107 |

**PART III: Consumption and distribution**

|   |     |
|---|-----|
| <i>Hellenistic Pergamene tableware in the northern Black Sea region</i>   |     |
| – by D. Zhuravlev, Gosudarstvennyj Istoricheskij Muzej, Moskva. . . . .   | 129 |
| <i>The Pitane workshop and the most successful export of Eastern Sigillata C</i>  |     |
| – by K. Domżalski, Instytut Archeologii i Etnologii, Polska Akademia Nauk, Warszawa. . . . .  | 151 |
| <i>Eastern sigillatas (ESA, „Pergamene“ and others) in the Delos houses : proportions and uses</i>  |     |
| – by A. Peignard-Giros, HiSoMA (Histoire et Sources des Mondes Antiques), CNRS UMR 5189, Maison de l’Orient et de la Méditerranée, Lyon . . . . . | 161 |
| <i>So-called Pergamenian Sigillata from Delos: post-analysis review of evidence</i>   |     |
| – by H. Meyza, Instytut Kultur Śródziemnomorskich i Orientalnych, Polska Akademia Nauk, Warszawa. . . . .   | 171 |
| <i>Late Roman Light Coloured Ware from Parion</i>   |     |
| – by H.E. Ergürer, Karamanoğlu Mehmetbey Üniversitesi, Karaman . . . . .  | 175 |
| <i>LRC (Phocaean) ware pottery in the urban context of Hippos – Susita</i>  |     |
| – by J. Mlynarczyk, Instytut Kultur Śródziemnomorskich i Orientalnych, Polska Akademia Nauk, Warszawa . . . . .                                   | 193 |
| REFERENCES . . . . .  | 201 |
| INDEX . . . . .   | 217 |

# Long-term pottery production and chemical reference groups: examples from Medieval Western Turkey\*

Sylvie Yona Waksman

Although research on archaeological sites in Western Asia Minor has mainly focused on the Greco-Roman periods, the later, Medieval and post-Medieval, contexts gradually tend to be both better documented in the archaeological record and better studied for its pottery.<sup>1</sup> In parallel, the development of archaeometric research has provided tools for more comprehensive approaches to production and diffusion of ceramics of these periods. A network of chemical reference data, based on the study of archaeologically attested workshops, has gradually been built for these productions at the “Laboratoire de Céramologie” in Lyon (Pergamon, Ephesos, Nicea/Iznik, Anaia/Kadıkalesi, Çanakkale, etc.).<sup>2</sup> In some of these sites, such as Pergamon and Ephesos, pottery manufacture is known in earlier periods as well and was investigated in several laboratories,<sup>3</sup> giving the opportunity to examine pottery analysis in a long-term perspective and to raise the

issue of the diachronic use of chemical reference groups. In many cases, local references lack, so that archaeological scientists may be tempted to use those - if any - which would be available for a given site, even if they do not correspond to the pottery types under study.

This paper considers chemical groups for different periods (Hellenistic to early Turkish) and different categories of wares (table, common, cooking wares) in two case studies, Pergamon and Ephesos. It builds upon previous work,<sup>4</sup> taking into account more recent analyses carried out in Lyon<sup>5</sup> and in Berlin.<sup>6</sup>

## Sampling for Medieval and post-Medieval reference groups and comparative material

The sampling considered includes sherds coming from Pergamon and Ephesos. The definition of chemical reference groups for Medieval and post-Medieval local production was based on the analysis of samples the local status of which is well attested, selected among pottery wasters and clayey kiln furniture. The latter mainly consisted of tripod stilts, used to stack glazed ceramics in the kilns.

### Pergamon (Figs. 1-2, Table 1)

In Pergamon, evidence of pottery production is present in several parts of the city, especially in the Ketios valley, where Hellenistic / Roman

<sup>1</sup> e.g. Böhendorf-Arslan 2004; *Spätantike und mittelalterliche*; Mania 2006, 475-501; Doğer 20132; *Byzantine craftsmen; Türbe*.

<sup>2</sup> Waksman & François 2004-2005, 629-724; Sauer & Waksman 2005, 51-66; Waksman & von Wartburg 2006, 369-88; Waksman 2013, 101-11; Waksman forthcoming.

<sup>3</sup> e.g. Jones 1986; Hughes et al. 1988, 461-85; Zabehlicky-Scheffenegger et al. 1996, 41-59; Schneider 2000, 525-36; Akurgal et al. 2002; Schneider & Japp 2009, 287-306; Mommsen & Japp 2009, 269-86; Okyar et al. 2011, 155-78.

<sup>4</sup> Waksman 1995; Zabehlicky-Scheffenegger et al. 1996, 41-59; Waksman et al. 1996, 209-18; Waksman & Spieser 1997, 105-33; Zabehlicky-Scheffenegger & Schneider 2000, 105-12; Sauer & Waksman 2005, 51-66.

<sup>5</sup> this paper; Waksman forthcoming.

<sup>6</sup> Schneider & Japp 2009, 287-306.

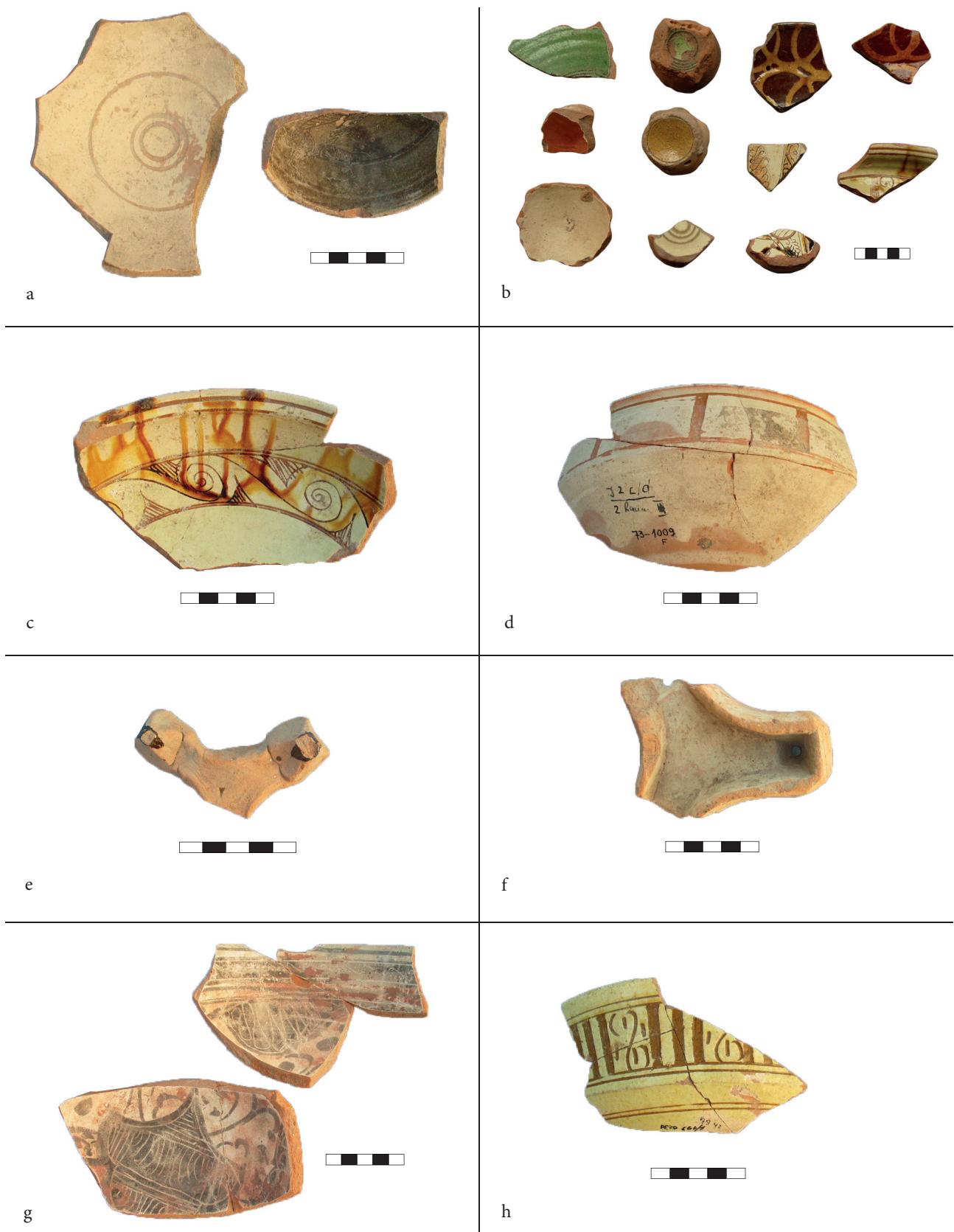


Figure 1: Examples of ceramics analyzed from Pergamon, local references and finished products shown to be local; chemical group B (Byzantine quarters): a-d; chemical group A (Red Hall): e-h (samples numbers given from left to right; pictures S.Y. Waksman); a) biscuit fired wasters (BZY410-411); b) various types of local wares, after Waksman 1995; c-d) "Zeuxippus related ware", with reverse typical for this region of Western Turkey (BZY415); e-f) tripod stilt (BZY446) and tripod stilts mould (BZY453); g) biscuit fired waster of "Miletus Ware" (BZY443); h) BZY417.

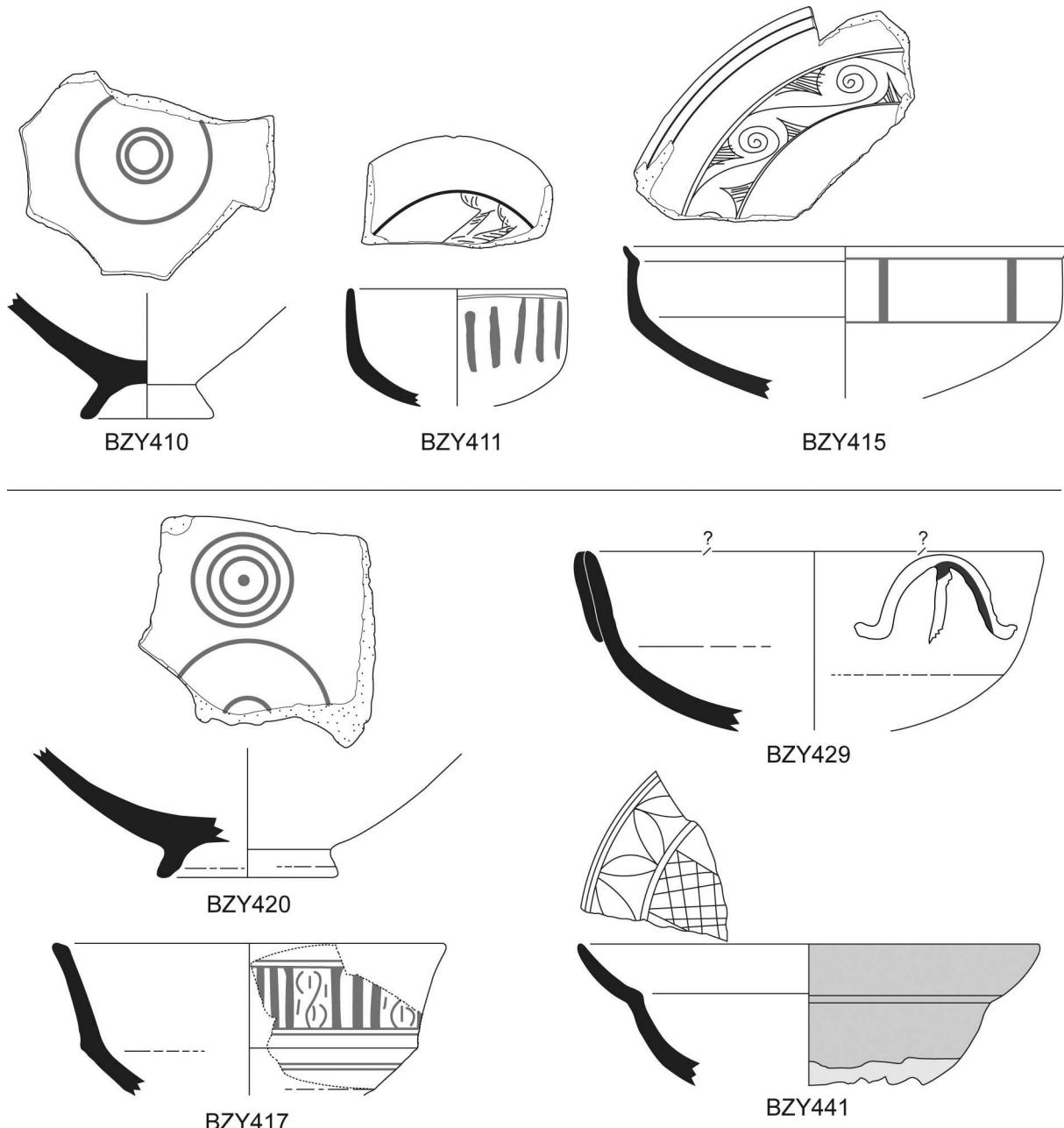


Figure 2: Examples of ceramics analyzed from Pergamon, belonging to local group B (top) and A (bottom) (scale 1/3, S.Y. Waksman, Pergamon team, J. Burlot).

workshops were found;<sup>7</sup> in late Byzantine living quarters on the slopes of the antique city, where fainter but clear evidence is present;<sup>8</sup> in the lower city, where the Red Hall may have been partly reoccupied by an early Turkish pottery workshop dated back to the 14th century.<sup>9</sup>

<sup>7</sup> Bounegru this volume; Japp 2009, 193–268, for a review of earlier bibliography.

<sup>8</sup> cf. *supra*; Rheidt 1991; Waksman 1995; Spieser 1996; Böhlerdorf Arslan 2004; Japp 2010, 862–75.

<sup>9</sup> Mania 2006, 475–501.

Reference groups for Medieval productions had previously been defined by PIXE and INAA in Strasbourg.<sup>10</sup> However, although previous results were taken into account, new Medieval reference groups were constituted in order to avoid limitations in statistical treatments.<sup>11</sup> They were also extended to early Turkish productions.

<sup>10</sup> Waksman 1995; Waksman *et al.* 1996, 209–18; Waksman & Spieser 1997, 105–33.

<sup>11</sup> Waksman 2006, 563–8.

Reference samples were selected as follows:

- from the Byzantine living quarters: tripod stilts (BZY412-413, 778) and wasters consisting in biscuit-fired unfinished wares, either without slip (BZY779-780) or decorated in the sgraffito technique (BZY410-411, Fig. 1a);
- from the Red Hall workshop: tripod stilts of both similar and larger sizes (BZY446-447, Fig. 1e)<sup>12</sup> together with an exceptional tripod mould (BZY453, Fig. 1f); biscuit-fired unfinished wares decorated with sgraffito and/or painted decoration, related to the type "Miletus Ware" (BZY443, 449-452, Fig. 1g).<sup>13</sup> Four of the samples taken from the Red Hall contexts were previously selected by S. Japp and analyzed in Bonn and Berlin.<sup>14</sup>

Next to reference samples, our sampling also included finished products, such as plain glazed and sgraffito wares (Figs. 1-2, Table 1). Their selection did not so much aim at defining the local repertoire, already investigated in previous work for the Byzantine period and shown to consist in a variety of types, styles and decoration techniques (Fig. 1b),<sup>15</sup> but at completing the "typological picture" and at giving the new chemical groups a better statistical representativity.

Concerning earlier Pergamene productions, although data were available in Lyon database we relied for these periods on reference groups well-documented on archaeological and typological grounds, which mainly consist of fine wares.<sup>16</sup> Among these groups, constituted in Bonn and Berlin, we used the latter, which are directly comparable to Lyon's.<sup>17</sup> The analytical method used in Lyon and in Berlin is the same (WD-XRF) and data had previously been exchanged between the two laboratories.

### Ephesos (Figs. 3-4, Table 1)

Evidence of pottery production in the late Byzantine and early Turkish periods is present

<sup>12</sup> Mania 2006, 490.

<sup>13</sup> Mania 2006, 475-501.

<sup>14</sup> Mommsen & Japp 2009, 269-86; Japp 2009, 193-268; Schneider & Japp 2009, 287-306. The following update applies to the two last papers: Perga 116 = Perga 121, Perga 117 = Perga 122, Perga 118 = Perga 123, Perga 119 = Perga 124. We would like to thank Sarah Japp for checking this point with us.

<sup>15</sup> Waksman 1995; Waksman & Spieser 1997, 105-33.

<sup>16</sup> Japp 2009, 193-268.

<sup>17</sup> Schneider & Japp 2009, 287-306.

in several locations in the surroundings of the Artemision in Selçuk, a few kilometers away from the antique city of Ephesus.<sup>18</sup> Reference groups had been constituted in Lyon with ceramics coming from ancient excavations in the Artemision and from recent ones in the nearby Türbe.<sup>19</sup> For the present study, samples were also taken from two other excavations, the Tribune and the Isa Bey hammam.

Reference samples included (Fig. 3, Table 1):

- tripod stilts (BYZ449, BZY332-333), coming from the Türbe and the Artemision contexts;
- biscuit-fired sherds (BZY377(?)378), over-fired sherds (BZY284-286) and pieces of clayey material (BZY334-335) found in a pottery production context located under the Türbe, dated back to the late Byzantine period (end of 13th - first half of the 14th century);<sup>20</sup>
- moulded wares, both glazed and unglazed, found together with their moulds, attributed to the early Turkish / Beylik period (Fig. 3f, BYZ439-442, BZY373).<sup>21</sup>

The corpus of finished products considered covered a larger range than in the case of Pergamon. It included a variety of late Byzantine and early Turkish table wares, plain glazed or with painted and/or sgraffito decoration (Figs. 3-4, Table 1).<sup>22</sup> It also extended to the following late Roman and Medieval common and cooking wares:

- so-called "Aegean" late Roman cooking wares, some of which may have been produced in Ephesos;<sup>23</sup>
- common wares with mica-coated surfaces, dated back to the Byzantine or Turkish period (BYZ443-446, BZY395-396, Fig. 3g);<sup>24</sup>
- amphorae, basins and other common wares with buff pastes from the Isa Bey hammam (BZY400-408, Fig. 3h), dated back to the Byzantine or Turkish period.<sup>25</sup>

<sup>18</sup> Vroom 2005, 17-49; Pfeiffer Taş 2011, 91-154; Parrer forthcoming; Vroom & Findik forthcoming.

<sup>19</sup> Sauer & Waksman 2005, 51-66; Waksman forthcoming.

<sup>20</sup> Parrer forthcoming; Vroom & Findik forthcoming.

<sup>21</sup> Vroom 2005, 34-5, type 6; Vroom & Findik forthcoming.

<sup>22</sup> Vroom 2005, 28-32, types 2 to 5; Waksman forthcoming; Vroom & Findik forthcoming.

<sup>23</sup> Turnovsky 2005b, 635-45; Waksman & Tréglia 2007, 645-57.

<sup>24</sup> Vroom 2005, 35-6, type 7.

<sup>25</sup> Vroom & Findik forthcoming.

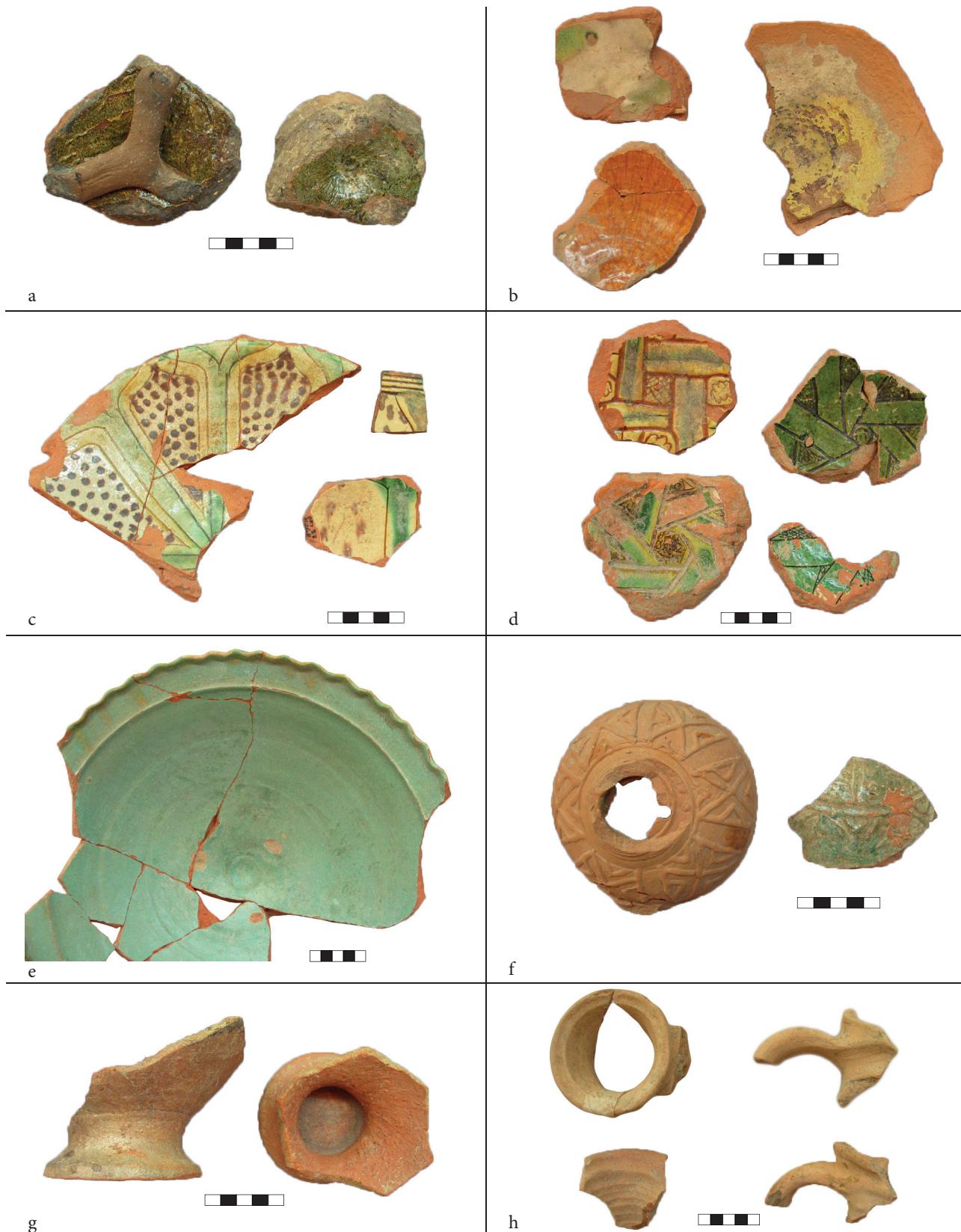


Figure 3: Examples of ceramics analyzed from Ephesos; samples from local groups b/2 and c/4: b-f; other local or possibly local groups: g-h (samples numbers given from left to right, top to bottom; pictures S.Y. Waksman).  
 a) tripod stilt stuck to a plain glazed base (not sampled); b) plain glazed and painted wares (BZY381-382, 380); c) polychrome sgraffito wares, Vroom 2005 type 3 (BYZ431 or 432, BZY364, 363); d) polychrome sgraffito wares, Vroom 2005 type 4 (BZY393, [not analyzed], 394, 392); e) turquoise-glazed ware (BYZ428); f) moulded wares (not analyzed, BZY373); g) mica-coated wares (BZY395-396); h) buff common wares (BZY400, 403, 401-402).

Table 1: Bibliographical information concerning samples illustrated in the literature.

| lab. id.        | catalogue / figure                                       |
|-----------------|--|
| <b>Pergamon</b> |  |
| BYZ 1           | Waksman 1995, BY-89                                      |
| BYZ 2           | Waksman 1995, BY-93                                      |
| BYZ 3           | Waksman 1995, CY-84                                      |
| BYZ239          | Waksman 1995, JY-114                                     |
| BZY415          | Spieser 1996, cat. 433                                   |
| BZY417          | Spieser 1996, cat. 430                                   |
| BZY418          | Spieser 1996, cat. 335                                   |
| BZY419          | Spieser 1996, cat. 66                                    |
| BZY420          | Spieser 1996, cat. 86                                    |
| BZY421          | Spieser 1996, cat. 249                                   |
| BZY423          | Spieser 1996, cat. 127                                   |
| BZY424          | Spieser 1996, cat. 199; Böhlendorf-Arslan 2004 pl. 185:3 |
| BZY429          | Spieser 1996, cat. 284                                   |
| BZY443          | Mania 2006 cat. 8; Japp 2009, Perga 116                  |
| BZY444          | Mania 2006 cat. 20 or 23?; Japp 2009, Perga 117          |
| BZY445          | Japp 2009, Perga 118                                     |
| BZY446          | Mania 2006, cat. 43; Japp 2009, Perga 119                |
| BZY447          | Mania 2006, cat. 43                                      |
| BZY449          | Mania 2006, cat. 4                                       |
| BZY450          | Mania 2006, cat. 6                                       |
| BZY451          | Mania 2006, cat. 9                                       |
| BZY452          | Mania 2006, cat. 3                                       |
| BZY453          | Mania 2006, cat. 45                                      |
| BZY454          | Mania 2006, cat. 17                                      |
| BZY455          | Mania 2006, cat. 31                                      |
| BZY778          | Waksman 1995, AY-56                                      |
| BZY779          | Waksman 1995, AY-73                                      |
| BZY780          | Waksman 1995, AY-81                                      |
| BZY781          | Waksman 1995, BY-38                                      |
| BZY782          | Waksman 1995, CY-150                                     |
| <b>Ephesos</b>  |  |
| BYZ428          | Vroom 2005, cat. 24                                      |
| BYZ431/2?       | Vroom 2005, cat. 17                                      |
| BZY284          | Waksman forth. fig. 2, Vroom and Findik forth., cat. 219 |

|        |  |
|--------|--|
| BZY285 | Waksman forth. fig. 2, Vroom and Findik forth., cat. 217 |
| BZY286 | Vroom and Findik forthcoming, cat. 218                   |
| BZY287 | Vroom and Findik forthcoming, cat. 82                    |
| BZY295 | Waksman forth. fig. 2, Vroom and Findik forth., cat. 68  |
| BZY298 | Waksman forthcoming, fig. 1                              |
| BZY323 | Waksman forth. fig. 6, Vroom and Findik forth., cat. 76  |
| BZY331 | Waksman forth. fig. 2, Vroom and Findik forth., cat. 66  |
| BZY332 | Waksman forth. fig. 2, Vroom and Findik forth., cat. 212 |
| BZY334 | Waksman forthcoming, fig. 1                              |
| BZY335 | Waksman forthcoming, fig. 1                              |
| BZY362 | Vroom 2005, cat. 22                                      |
| BZY365 | Vroom 2005, cat. 25                                      |
| BZY372 | Vroom and Findik forthcoming, cat. 93                    |
| BZY373 | Waksman forth. fig. 3, Vroom and Findik forth., cat. 144 |
| BZY377 | Waksman forth. fig. 1, Vroom and Findik forth., cat. 108 |
| BZY379 | Vroom and Findik forthcoming, cat. 81                    |
| BZY380 | Vroom and Findik forthcoming, cat. 113                   |
| BZY381 | Waksman forthcoming, fig. 2                              |
| BZY382 | Waksman forthcoming, fig. 3                              |
| BZY383 | Waksman forthcoming, fig. 2                              |

Comparative data for Hellenistic and Roman wares attributed to Ephesos were taken from Schneider's analyses of table wares, especially "Graue Platten" from Ephesos and from the Madgalensberg.<sup>26</sup>

### Chemical analysis and statistical handling of data

Chemical analysis of the samples was carried out by Wavelength Dispersive - X Ray Fluorescence (WD-XRF) at the "Laboratoire de Céramologie" in Lyon. Twenty-four elements are quantified, seventeen of which are usually taken as active variables in multivariate statistical treatments used to classify ceramics into groups of similar chemical composition. These include eight major and

minor elements in ceramics ( $MgO$ ,  $Al_2O_3$ ,  $SiO_2$ ,  $K_2O$ ,  $CaO$ ,  $TiO_2$ ,  $MnO$ ,  $Fe_2O_3$ ) and nine trace elements (V, Cr, Ni, Zn, Rb, Sr, Zr, Ba, Ce).<sup>27</sup>

Classifications of the samples are obtained by hierarchical clustering analysis applied to standardized data, using euclidian distance and average linkage.<sup>28</sup> The corresponding diagram, called a dendrogram, initially represents each sample as a vertical bar at the bottom of the figure (Fig.5). The two samples that are the most alike in elemental composition are connected by a horizontal link, which is placed lower the more chemically similar the samples are. The two samples are then fused into a "pseudo sample" of average composition. The same process is repeated, with the linkage being formed at growing heights, until all the samples are connected. The resulting diagram constitutes the dendrogram. It shows clusters or groups of samples of similar composition linked

<sup>26</sup> Zabehlicky-Scheffenegger *et al.* 1996, 41-59; Zabehlicky-Scheffenegger & Schneider 2000, 105-12; Schneider 2000, 525-36.

<sup>27</sup> Ce was not taken into account here.

<sup>28</sup> e.g. Picon 1984, 379-99.

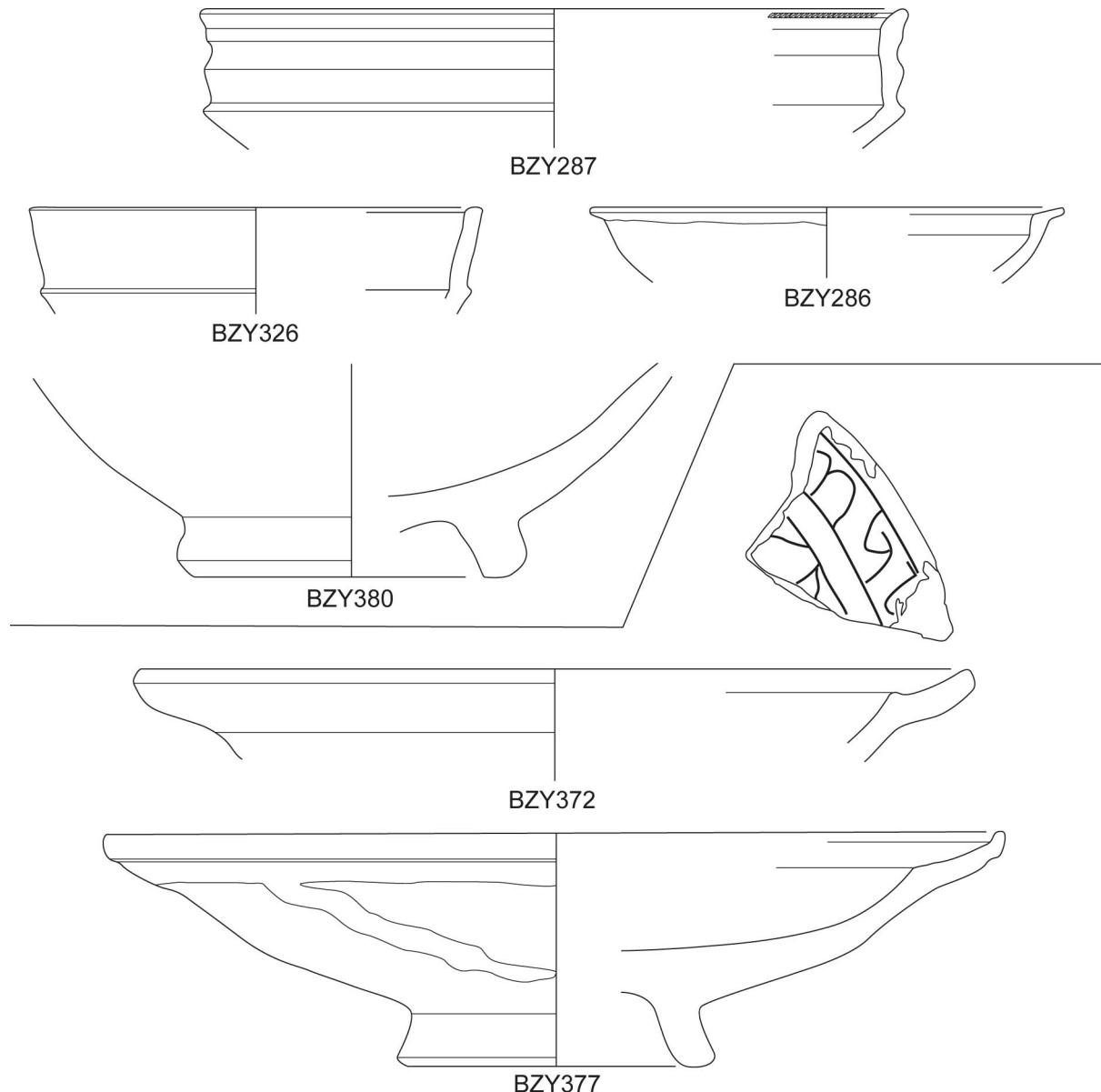


Figure 4: Examples of ceramics analyzed from Ephesus, belonging to local group c/4 (top) and b/2 (bottom) (scale 1/3, Ephesus team, N. Math, S.Y. Waksman).

at a lower level, all the clusters being ultimately linked together at the top of the diagram. This representation is not sufficient in itself to define compositional groups, as it does not take into account the significance of elemental differences between clusters. Further examination of the raw data is still needed in order to be able to interpret classifications in terms of productions and workshops.<sup>29</sup>

## Results and discussion

Classifications according to their chemical compositions of samples of different periods and categories were carried out for each site. In a first phase, we excluded sherds likely to correspond to imports, in order to focus on local production. The latter mostly corresponds to chemical groups including reference samples. In some cases, we kept samples or groups which did not include reference samples *stricto sensu* (indicated by black dots in Fig.5), but were likely to be local as well.

<sup>29</sup> Picon 1993, 3-25.

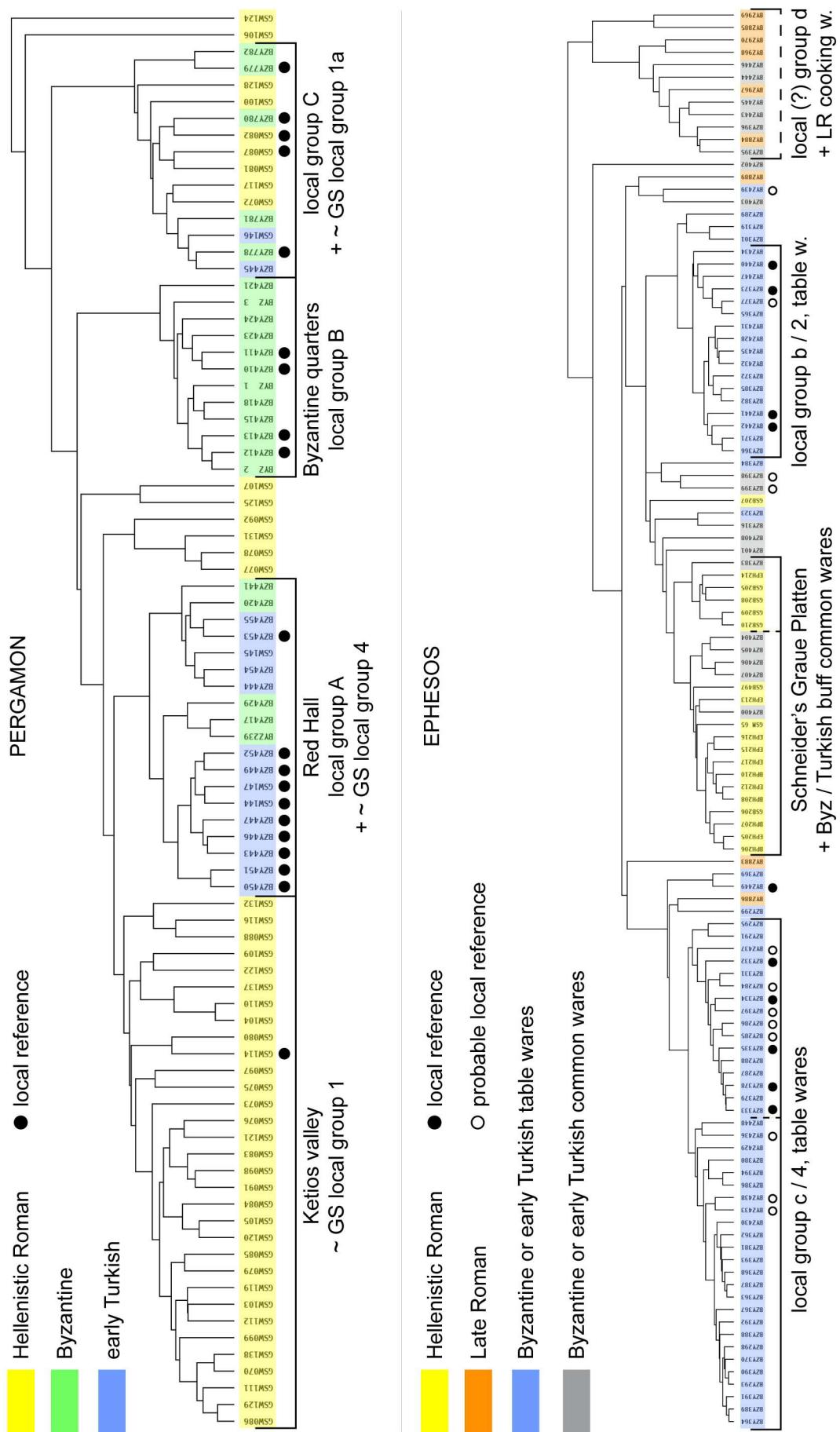


Figure 5: Classifications according to chemical compositions of ceramics from Pergamon (top) and from Ephesos (bottom), local productions of various periods and categories mainly.

Data from Lyon and Berlin laboratories, the latter include comparative data for samples from the Magdalensberg (cf. text).

Samples are identified by their laboratory number, colours refer to chronological information, symbols point out reference samples for local production. The main chemical groups are underlined, correspondences with G. Schneider's and with our previous groups (Sauer and Waksman 2005, Schneider and Japp 2009, Waksman forthcoming) are indicated.

In Pergamon, the classification (Fig. 5, top) presents different situations. As far as we can see within the limits of the sampling considered, some of the groups show no mixing, containing respectively Hellenistic and Roman ceramics from the Ketios valley (GS local group 1)<sup>30</sup> and wares from the Byzantine living quarters (local group B). The latter corresponds to the main production of Byzantine table wares, as defined in previous work based on a more extensive sampling.<sup>31</sup> A variety of wares belongs to it (plain glazed, slip-painted, monochrome and polychrome sgraffito wares, Fig. 1b), including ceramics related to the type “Zeuxippus ware” (Fig. 1c-d).<sup>32</sup>

Another group (local group A), corresponding to Schneider’s group 4,<sup>33</sup> shows little mixing as it mostly gathers early Turkish reference samples from the Red Hall, together with plain green glazed wares from the same contexts. However, it also includes sherds usually dated back to the Byzantine period (e.g. BZY417, 420, Figs. 1h, 2), which questions the chronology of the beginnings of this production.

Another interpretation is that it corresponds to clays coming from the same geological formations, exploited by workshops operating at different periods, an interpretation which can be put forward for the composite group C, containing samples dated back from the Hellenistic to the early Turkish periods (Fig. 5). It approximately corresponds to Schneider’s group 1a,<sup>34</sup> including two overfired sherds from the Ketios valley contexts (GSW082<sup>35</sup> [Perga 28], GSW087 [Perga 34]). It also includes the minor Byzantine group byzi<sup>36</sup> containing reference samples from the Byzantine quarters (BZY778-780).<sup>37</sup> In addition, one green

glazed sherd coming from the Red Hall contexts belongs to it (BZY445, same sample as GSW146 [Perga 123]).

The chemical features of the different groups give only a few clues (Table 2). The location downhill of the Red Hall workshop (group A) may explain its sharing many chemical features with the Ketios valley group 1: higher aluminium, potassium, iron, titanium, vanadium, etc., relatively to group B from the Byzantine quarters uptown. The highest concentrations in these elements and in magnesium are observed in group C/1a, which also has the lowest calcium contents. Ketios group 1 is differentiated from the other groups by higher chromium and nickel contents (see also group hell<sup>38</sup>).<sup>39</sup> Post-depositional processes are probably responsible for the large standard deviations in strontium and baryum.<sup>40</sup>

The two main groups (Hellenistic / Roman group 1 and Byzantine group B), which are likely to represent a large part of the production at their respective periods, have chemical features which suggest the exploitation of different clay sources rather than the use of the same raw material treated differently (e.g. through clay levigation for the earlier fine wares). The geochemical variability of clay materials available in the vicinity of Pergamon (and in this region of Western Turkey in general) makes it possible to distinguish chemical groups within a limited geographical area. That these groups correspond to some extent to productions of specific periods might be connected to the location of the workshops.<sup>41</sup> Still, we have no information regarding clay procurement around the workshop or workshops area. And as we have seen this correspondence is not the general rule.

The Pergamene evidence presents a complex situation. Although three main chemical groups, fairly well correlated with (large) chronological periods, may be pointed out (Hellenistic and Roman group 1, late Byzantine group B, (late

<sup>30</sup> after Schneider & Japp 2009, 287-306.

<sup>31</sup> Waksman 1995; Waksman & Spieser 1997, 105-33.

<sup>32</sup> Megaw 1968, 67-88; Waksman & François 2004-2005, 629-724.

<sup>33</sup> Schneider & Japp 2009, 287-306.

<sup>34</sup> As indicated in Schneider & Japp 2009, 292, some sherds from Ketios groups 1 and 1a may be attributed to one or another of these groups. This trend explains why some of the samples initially in Schneider’s group 1a cluster with group 1 in the classification (Fig. 5 top).

<sup>35</sup> The correspondence with sample numbers in Schneider & Japp 2009, 287-306, is as follows: GSW (this work) = W (Schneider & Japp 2009, 287-306). Catalogue entries in Japp 2009, 193-268, are indicated between brackets.

<sup>36</sup> after Waksman 1995; Waksman & Spieser 1997, 105-33.

<sup>37</sup> Waksman 1995; Waksman & Spieser 1997, 105-33.

<sup>38</sup> after Waksman 1995; Waksman & Spieser 1997, 105-33, Schneider & Japp 2009, 287-306.

<sup>39</sup> Waksman 1995; Waksman & Spieser 1997, 105-33, Schneider & Japp 2009, 287-306.

<sup>40</sup> Picon 1987, 41-7. Sr and Ba were not taken into account in the classification Fig. 5 (top).

<sup>41</sup> However, unlike the Ketios installations, the location of the Byzantine and early Turkish ones is not attested by kilns or other workshops structures and the evidence found might be in secondary position.

Table 2: Chemical compositions of samples from Pergamon analyzed in Lyon, ranked as in the dendrogram (Fig. 5, top), together with comparative data from Berlin. Major and minor elements are given in oxides weight %, trace elements in parts per million (ppm); m: mean,  $\sigma$ : standard deviation, n: number of samples, ld: detection limits. Elements within brackets are indicative.

| id.   | CaO         | Fe <sub>2</sub> O <sub>3</sub> | TiO <sub>2</sub> | K <sub>2</sub> O | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | MgO         | MnO           | (Na <sub>2</sub> O) | (P <sub>2</sub> O <sub>5</sub> ) | Zr         | Sr         | Rb         | Zn        | Cr         | Ni         | (La)      | Ba         | V          | (Ce)       |
|---|-------------|--------------------------------|------------------|------------------|------------------|--------------------------------|-------------|---------------|---------------------|----------------------------------|------------|------------|------------|-----------|------------|------------|-----------|------------|------------|------------|
| Rotte Halle and local early Turkish production mainly |             |                                |                  |                  |                  |                                |             |               |                     |                                  |            |            |            |           |            |            |           |            |            |            |
| BZY450  | 5,29        | 6,48                           | 0,858            | 2,97             | 61,68            | 17,46                          | 2,88        | 0,1161        | 1,74                | 0,27                             | 190        | 427        | 129        | 89        | 109        | 68         | 39        | 971        | 133        | 124        |
| BZY451  | 4,91        | 6,50                           | 0,862            | 3,04             | 61,91            | 17,49                          | 2,81        | 0,1158        | 1,87                | 0,23                             | 197        | 411        | 132        | 94        | 113        | 76         | 43        | 982        | 146        | 117        |
| BZY443  | 4,12        | 7,10                           | 0,950            | 3,33             | 60,66            | 18,51                          | 3,24        | 0,1185        | 1,49                | 0,21                             | 210        | 381        | 141        | 91        | 134        | 79         | 59        | 853        | 153        | 106        |
| BZY446  | 5,15        | 6,92                           | 0,931            | 3,36             | 59,65            | 18,59                          | 3,25        | 0,1098        | 1,49                | 0,24                             | 207        | 400        | 138        | 93        | 117        | 76         | 49        | 897        | 154        | 129        |
| BZY447  | 4,22        | 7,03                           | 0,931            | 3,57             | 60,06            | 18,96                          | 3,14        | 0,1178        | 1,49                | 0,21                             | 217        | 355        | 149        | 92        | 121        | 71         | 43        | 853        | 158        | 121        |
| BZY449  | 5,22        | 6,76                           | 0,890            | 3,36             | 60,25            | 18,22                          | 2,95        | 0,1053        | 1,70                | 0,29                             | 217        | 400        | 130        | 90        | 118        | 79         | <ld       | 915        | 143        | 127        |
| BZY452  | 5,41        | 6,64                           | 0,886            | 3,16             | 61,04            | 17,61                          | 2,96        | 0,1150        | 1,66                | 0,23                             | 208        | 406        | 130        | 87        | 119        | 73         | 69        | 916        | 155        | 120        |
| BYZ239  | 5,99        | 7,05                           | 0,908            | 3,82             | 57,63            | 19,56                          | 3,29        | 0,1123        | 1,18                | 0,23                             | 227        | 271        | 158        | 93        | 121        | 86         | 43        | 927        | 136        | 94         |
| BZY417  | 5,98        | 6,99                           | 0,903            | 3,78             | 58,01            | 19,29                          | 3,24        | 0,1217        | 1,07                | 0,38                             | 213        | 274        | 158        | 95        | 120        | 84         | 46        | 879        | 141        | 132        |
| BZY429  | 5,76        | 6,84                           | 0,888            | 3,49             | 59,55            | 18,41                          | 3,01        | 0,1140        | 1,47                | 0,24                             | 219        | 304        | 145        | 92        | 129        | 79         | 57        | 818        | 130        | 112        |
| BZY444  | 3,55        | 7,79                           | 1,035            | 3,61             | 58,78            | 19,81                          | 3,64        | 0,1158        | 1,23                | 0,21                             | 213        | 307        | 153        | 105       | 135        | 92         | 47        | 807        | 160        | 113        |
| BZY454  | 3,53        | 7,90                           | 1,042            | 3,79             | 57,97            | 20,19                          | 3,71        | 0,1177        | 1,33                | 0,20                             | 219        | 306        | 161        | 102       | 141        | 97         | <ld       | 764        | 175        | 113        |
| BZY453  | 4,37        | 7,24                           | 0,946            | 3,80             | 58,65            | 19,48                          | 3,43        | 0,1148        | 1,49                | 0,23                             | 219        | 366        | 151        | 97        | 134        | 82         | 58        | 832        | 163        | 103        |
| BZY455  | 3,74        | 7,29                           | 0,955            | 3,56             | 59,93            | 19,19                          | 3,29        | 0,1216        | 1,43                | 0,22                             | 216        | 348        | 158        | 98        | 127        | 85         | 49        | 853        | 168        | 114        |
| BZY420  | 3,93        | 7,44                           | 0,985            | 3,58             | 59,44            | 19,20                          | 3,44        | 0,1198        | 1,34                | 0,26                             | 236        | 247        | 152        | 107       | 155        | 107        | 51        | 891        | 153        | 111        |
| BZY441  | 2,50        | 7,72                           | 1,002            | 3,64             | 59,80            | 19,83                          | 3,33        | 0,1122        | 1,36                | 0,36                             | 218        | 290        | 168        | 102       | 135        | 72         | 57        | 921        | 172        | 127        |
| <b>m</b>  | <b>4,60</b> | <b>7,11</b>                    | <b>0,936</b>     | <b>3,49</b>      | <b>59,69</b>     | <b>18,86</b>                   | <b>3,23</b> | <b>0,1155</b> | <b>1,46</b>         | <b>0,25</b>                      | <b>214</b> | <b>343</b> | <b>147</b> | <b>95</b> | <b>127</b> | <b>82</b>  | <b>51</b> | <b>880</b> | <b>153</b> | <b>116</b> |
| <b><math>\sigma</math></b>                            | <b>1,01</b> | <b>0,44</b>                    | <b>0,057</b>     | <b>0,27</b>      | <b>1,27</b>      | <b>0,86</b>                    | <b>0,26</b> | <b>0,0043</b> | <b>0,21</b>         | <b>0,05</b>                      | <b>11</b>  | <b>58</b>  | <b>12</b>  | <b>6</b>  | <b>12</b>  | <b>10</b>  | <b>8</b>  | <b>59</b>  | <b>14</b>  | <b>10</b>  |
| Byzantine quarters, main local group                  |             |                                |                  |                  |                  |                                |             |               |                     |                                  |            |            |            |           |            |            |           |            |            |            |
| <b>m</b>  | <b>5,39</b> | <b>7,16</b>                    | <b>1,001</b>     | <b>3,37</b>      | <b>60,56</b>     | <b>18,60</b>                   | <b>2,90</b> | <b>0,1110</b> | <b>0,60</b>         | <b>0,213</b>                     | <b>182</b> | <b>317</b> | <b>144</b> | <b>94</b> | <b>257</b> | <b>156</b> | <b>36</b> | <b>685</b> | <b>153</b> | <b>83</b>  |
| <b><math>\sigma</math></b>                            | <b>1,87</b> | <b>0,51</b>                    | <b>0,076</b>     | <b>0,26</b>      | <b>2,20</b>      | <b>1,11</b>                    | <b>0,45</b> | <b>0,028</b>  | <b>0,17</b>         | <b>0,046</b>                     | <b>12</b>  | <b>71</b>  | <b>12</b>  | <b>15</b> | <b>29</b>  | <b>19</b>  | <b>9</b>  | <b>112</b> | <b>18</b>  | <b>7</b>   |
| BYZ 2   | 6,84        | 5,94                           | 0,741            | 2,83             | 63,26            | 17,57                          | 2,48        | 0,1173        | 1,74                | 0,28                             | 217        | 346        | 140        | 84        | 95         | 71         | 43        | 985        | 103        | 91         |

| id.                        | CaO         | Fe <sub>2</sub> O <sub>3</sub> | TiO <sub>2</sub> | K <sub>2</sub> O | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | MgO         | MnO           | (Na <sub>2</sub> O) | (P <sub>2</sub> O <sub>5</sub> ) | Zr         | Sr         | Rb         | Zn        | Cr        | Ni        | (La)      | Ba          | V          | (Ce)       |
|----------------------------|-------------|--------------------------------|------------------|------------------|------------------|--------------------------------|-------------|---------------|---------------------|----------------------------------|------------|------------|------------|-----------|-----------|-----------|-----------|-------------|------------|------------|
| BZY412                     | 6,12        | 5,79                           | 0,711            | 2,89             | 62,78            | 17,21                          | 2,33        | 0,1148        | 1,54                | 0,21                             | 218        | 355        | 135        | 85        | 92        | 64        | 51        | 967         | 112        | 96         |
| BZY413                     | 6,51        | 5,70                           | 0,695            | 2,98             | 62,31            | 16,87                          | 2,52        | 0,1111        | 1,61                | 0,29                             | 196        | 389        | 131        | 83        | 89        | 58        | 53        | 1041        | 109        | 121        |
| BZY415                     | 8,91        | 5,97                           | 0,730            | 2,63             | 60,61            | 16,65                          | 2,60        | 0,1223        | 1,32                | 0,20                             | 196        | 322        | 131        | 86        | 99        | 67        | <ld       | 905         | 103        | 124        |
| BZY418                     | 7,58        | 6,01                           | 0,735            | 2,67             | 61,82            | 16,89                          | 2,43        | 0,1222        | 1,29                | 0,22                             | 204        | 314        | 134        | 86        | 101       | 62        | 47        | 925         | 109        | 125        |
| BYZ_1                      | 7,70        | 5,96                           | 0,737            | 2,86             | 61,89            | 17,80                          | 2,71        | 0,1156        | 1,56                | 0,21                             | 187        | 344        | 141        | 81        | 89        | 70        | 45        | 1090        | 117        | 86         |
| BZY410                     | 7,51        | 5,61                           | 0,687            | 2,87             | 62,56            | 16,51                          | 2,23        | 0,1103        | 1,46                | 0,19                             | 178        | 355        | 122        | 86        | 94        | 64        | 59        | 1233        | 127        | 114        |
| BZY411                     | 7,24        | 5,91                           | 0,702            | 2,84             | 61,91            | 16,96                          | 2,51        | 0,1165        | 1,38                | 0,19                             | 166        | 339        | 130        | 88        | 100       | 65        | 53        | 981         | 130        | 115        |
| BZY423                     | 6,18        | 5,97                           | 0,722            | 2,90             | 62,82            | 16,97                          | 2,54        | 0,1083        | 1,32                | 0,22                             | 173        | 329        | 134        | 88        | 95        | 65        | 46        | 1028        | 105        | 112        |
| BZY424                     | 4,88        | 5,78                           | 0,696            | 2,90             | 64,30            | 17,03                          | 2,29        | 0,1080        | 1,57                | 0,21                             | 189        | 353        | 130        | 87        | 90        | 52        | 55        | 973         | 120        | 108        |
| BYZ_3                      | 7,94        | 6,34                           | 0,773            | 2,95             | 61,19            | 17,65                          | 2,84        | 0,1123        | 1,55                | 0,21                             | 176        | 315        | 138        | 96        | 101       | 78        | 38        | 979         | 116        | 83         |
| BZY421                     | 5,80        | 5,98                           | 0,742            | 2,75             | 63,31            | 17,01                          | 2,34        | 0,1501        | 1,42                | 0,25                             | 214        | 323        | 136        | 85        | 102       | 64        | 39        | 1091        | 101        | 106        |
| <b>m</b>                   | <b>6,93</b> | <b>5,91</b>                    | <b>0,723</b>     | <b>2,84</b>      | <b>62,40</b>     | <b>17,09</b>                   | <b>2,49</b> | <b>0,1174</b> | <b>1,48</b>         | <b>0,22</b>                      | <b>193</b> | <b>340</b> | <b>134</b> | <b>86</b> | <b>96</b> | <b>65</b> | <b>48</b> | <b>1017</b> | <b>113</b> | <b>107</b> |
| <b><math>\sigma</math></b> | <b>1,10</b> | <b>0,18</b>                    | <b>0,025</b>     | <b>0,11</b>      | <b>1,00</b>      | <b>0,40</b>                    | <b>0,18</b> | <b>0,0113</b> | <b>0,14</b>         | <b>0,03</b>                      | <b>18</b>  | <b>22</b>  | <b>5</b>   | <b>4</b>  | <b>5</b>  | <b>6</b>  | <b>7</b>  | <b>89</b>   | <b>10</b>  | <b>15</b>  |

main Byzantine local group (n=57, recalibrated data, Waksman and François 2004-2005 after Waksman 1995)

| <b>m</b>                                       | <b>7,04</b> | <b>5,79</b> | <b>0,757</b> | <b>2,90</b> | <b>61,10</b> | <b>17,18</b> |             | <b>0,1158</b> | <b>1,68</b> |              | <b>174</b> | <b>328</b> | <b>127</b> |            | <b>90</b>  | <b>76</b>  | <b>42</b>  | <b>1021</b> |            | <b>84</b>  |
|--|-------------|-------------|--------------|-------------|--------------|--------------|-------------|---------------|-------------|--------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|
| <b><math>\sigma</math></b>                     | <b>1,50</b> | <b>0,42</b> | <b>0,057</b> | <b>0,23</b> | <b>1,33</b>  | <b>0,58</b>  |             | <b>0,0085</b> | <b>0,17</b> |              | <b>49</b>  | <b>30</b>  | <b>11</b>  |            | <b>10</b>  | <b>17</b>  | <b>2</b>   | <b>123</b>  |            | <b>4</b>   |
| Byzantine quarters, minor local group          |             |             |              |             |              |              |             |               |             |              |            |            |            |            |            |            |            |             |            |            |
| BZY445   | 2,87        | 7,98        | 1,055        | 4,08        | 57,88        | 20,52        | 3,63        | 0,1149        | 1,23        | 0,26         | 255        | 251        | 165        | 108        | 163        | 106        | 44         | 712         | 165        | 113        |
| BZY778   | 2,24        | 8,23        | 1,084        | 4,05        | 57,72        | 20,75        | 3,89        | 0,1249        | 1,22        | 0,46         | 244        | 226        | 160        | 100        | 191        | 119        | 58         | 829         | 167        | 97         |
| BZY781   | 2,70        | 8,51        | 1,147        | 4,28        | 56,53        | 21,26        | 4,01        | 0,1216        | 0,98        | 0,22         | 236        | 172        | 171        | 110        | 176        | 122        | 57         | 626         | 156        | 112        |
| BZY780   | 2,20        | 8,68        | 1,152        | 4,04        | 57,40        | 21,38        | 3,45        | 0,1194        | 0,99        | 0,33         | 221        | 177        | 174        | 122        | 161        | 100        | 66         | 1025        | 179        | 85         |
| BZY779   | 3,37        | 9,05        | 1,157        | 4,58        | 53,56        | 22,53        | 4,58        | 0,1376        | 0,62        | 0,19         | 234        | 205        | 187        | 109        | 189        | 120        | 54         | 703         | 185        | 94         |
| BZY782   | 3,67        | 8,87        | 1,135        | 4,40        | 53,92        | 22,06        | 4,42        | 0,1242        | 0,74        | 0,41         | 250        | 228        | 177        | 110        | 190        | 120        | 66         | 833         | 171        | 101        |
| <b>m</b>                                       | <b>2,84</b> | <b>8,55</b> | <b>1,122</b> | <b>4,24</b> | <b>56,17</b> | <b>21,42</b> | <b>4,00</b> | <b>0,1238</b> | <b>0,96</b> | <b>0,31</b>  | <b>240</b> | <b>210</b> | <b>172</b> | <b>110</b> | <b>178</b> | <b>115</b> | <b>58</b>  | <b>788</b>  | <b>171</b> | <b>100</b> |
| <b><math>\sigma</math></b>                     | <b>0,59</b> | <b>0,40</b> | <b>0,042</b> | <b>0,22</b> | <b>1,94</b>  | <b>0,77</b>  | <b>0,44</b> | <b>0,0077</b> | <b>0,25</b> | <b>0,11</b>  | <b>12</b>  | <b>31</b>  | <b>9</b>   | <b>7</b>   | <b>14</b>  | <b>9</b>   | <b>8</b>   | <b>141</b>  | <b>10</b>  | <b>11</b>  |
| local group 1a (n=10, Schneider and Japp 2009) |             |             |              |             |              |              |             |               |             |              |            |            |            |            |            |            |            |             |            |            |
| <b>m</b>                                       | <b>2,71</b> | <b>7,94</b> | <b>1,091</b> | <b>4,24</b> | <b>57,96</b> | <b>21,56</b> | <b>3,25</b> | <b>0,1118</b> | <b>0,89</b> | <b>0,221</b> | <b>217</b> | <b>204</b> | <b>165</b> | <b>109</b> | <b>221</b> | <b>133</b> | <b>39</b>  | <b>817</b>  | <b>191</b> | <b>95</b>  |
| <b><math>\sigma</math></b>                     | <b>0,99</b> | <b>0,59</b> | <b>0,069</b> | <b>0,27</b> | <b>2,27</b>  | <b>1,44</b>  | <b>0,47</b> | <b>0,015</b>  | <b>0,35</b> | <b>0,056</b> | <b>24</b>  | <b>58</b>  | <b>11</b>  | <b>13</b>  | <b>17</b>  | <b>7</b>   | <b>113</b> | <b>26</b>   | <b>13</b>  |            |

Byzantine-) early Turkish group A), different chemical groups exist within a same chronology and for a same category of wares (table wares, as opposed to e.g. cooking wares). Conversely, at least one of the clay sources was exploited at different periods (group C). The latter group may be used as a Pergamene reference irrespectively of the period (at least within the chronological range considered), but it is little representative of the bulk of the production.

The next classification (Fig. 5 bottom), dealing with Ephesian productions, shows a complex picture as well. Two main chemical groups may be distinguished within late Byzantine and early Turkish glazed table wares (local groups b/2 and c/4).<sup>42</sup> Both correspond to low-calcareous pastes distinguished within the sampling by their higher concentrations in aluminium, potassium, vanadium, iron, etc., group c/4 presenting the highest contents of these elements and in rare earths whereas strontium and nickel are higher in b/2. Magnesium, chromium and nickel show large standard variations - a trend observed among the whole sampling - with a possible sub-group corresponding to higher values within group c/4. This sub-group gathers most of the polychrome sgraffito wares (Fig. 3c-d), whereas the rest of c/4 contains reference samples and wares attributed to the late Byzantine period from the Türbe contexts (Fig. 4 top).<sup>43</sup> Group b/2 seems to correspond more specifically to new types introduced later on in the local repertoire, especially moulded<sup>44</sup> (BYZ440-442, BZY373, Fig. 3f)<sup>45</sup> and turquoise-glazed<sup>46</sup> wares (BYZ428, BZY365-366, 371, Fig. 3e).<sup>47</sup> These involve technical traditions in pottery manufacture known in the Islamic world, which differ from those in use at the Byzantine period in the region.<sup>48</sup>

<sup>42</sup> The names of the groups refer to Sauer & Waksman 2005, 51-66, and Waksman forthcoming.

<sup>43</sup> Waksman forthcoming; Vroom & Findik forthcoming.

<sup>44</sup> As far as we know there is no evidence for the use of moulds between the Roman and the Beylik periods.

<sup>45</sup> Vroom 2005, 34-5, type 6.

<sup>46</sup> The flux used as a component of the glaze to manufacture turquoise-glazed ware includes alkali and not only lead as in the previous Byzantine period (Waksman 2005, 83-9; Armstrong *et al.* 1997, 225-9; see also Scott & Kamilli 1981, 679-96).

<sup>47</sup> Vroom 2005, 30-2, type 2.

<sup>48</sup> Waksman forthcoming.

The two other chemical groups contain samples from different periods, showing that Byzantine or early Turkish common wares were manufactured with clay materials already used previously. This is especially true of calcareous common wares (Fig. 3h) chemically similar to Schneider's group of table wares, which mainly consists of "Graue Platten". It is the only (moderately) calcareous group within the sampling, which is further distinguished by its lower iron and titanium concentrations.

The last "group" in the classification (Fig. 5 bottom) gathers mica-coated common wares dated back to the early Turkish period (Fig. 3g)<sup>49</sup>, together with late Roman "Aegean" cooking wares. It is not homogeneous and is not considered a chemical group *stricto sensu*. But its samples have in common several chemical features, including variable but usually high chromium and nickel and low potassium and rubidium contents. These features differentiate them from all the others. No reference samples belong to it, but the fact that it includes presumably Ephesian wares of different periods is in favour of a local origin.

The case of Ephesos shows trends similar to those observed in Pergamon: on the one hand different chemical groups for the same categories of wares at the same, or closely connected, periods;<sup>50</sup> on the other hand long-term use of some of the clay sources. Common wares seem to be more "conservative" in the use of raw materials, but in the present case they unexpectedly correspond to earlier wares which do not belong to the same functional or technical category: mica-coated wares, which do not seem to have the cooking function of their predecessors; and basins and amphorae following earlier table wares.

## Concluding remarks

Evidence of pottery production are archaeologically attested in Pergamon and Ephesus at the Hellenistic / Roman and the late Byzantine / early Turkish periods. In both sites, reference

<sup>49</sup> Vroom 2005, 35-6, type 7; Sauer & Waksman 2005, 51-66, group d.

<sup>50</sup> Further work is requested to investigate the correspondence between typo-chronological and chemical groups in the Byzantine and Turkish periods.

Table 3: Chemical compositions of samples from Ephesos analyzed in Lyon, ranked as in the dendrogram (Fig. 5, bottom), together with comparative data from Strasbourg and Berlin. Major and minor elements are given in oxides weight %, trace elements in parts per million (ppm); m: mean, σ: standard deviation, n: number of samples. Elements within brackets are indicative; data with an asterisk were not taken into account in the calculation of m and σ.

| id.  | CaO  | Fe <sub>2</sub> O <sub>3</sub> | TiO <sub>2</sub> | K <sub>2</sub> O | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | MgO  | MnO    | (Na <sub>2</sub> O) | (P <sub>2</sub> O <sub>5</sub> ) | Zr  | Sr  | Rb  | Zn  | Cr  | Ni  | (La) | Ba  | V   | (Ce) |
|--|------|--------------------------------|------------------|------------------|------------------|--------------------------------|------|--------|---------------------|----------------------------------|-----|-----|-----|-----|-----|-----|------|-----|-----|------|
| <b>local group c/4, late Byzantine and early Turkish table wares</b> |      |                                |                  |                  |                  |                                |      |        |                     |                                  |     |     |     |     |     |     |      |     |     |      |
| BZY364   | 1,32 | 11,68                          | 1,025            | 4,26             | 51,77            | 24,34                          | 3,39 | 0,1391 | 1,17                | 0,29                             | 229 | 159 | 178 | 157 | 171 | 97  | 79   | 819 | 214 | 160  |
| BZY389   | 1,49 | 11,79                          | 1,021            | 4,27             | 51,55            | 24,32                          | 3,36 | 0,1415 | 1,36                | 0,28                             | 230 | 162 | 176 | 160 | 164 | 87  | 97   | 819 | 218 | 158  |
| BZY391   | 1,41 | 11,57                          | 1,029            | 4,32             | 52,08            | 24,17                          | 3,54 | 0,1430 | 1,10                | 0,29                             | 227 | 162 | 178 | 158 | 170 | 100 | 64   | 827 | 213 | 158  |
| BZY293   | 1,46 | 11,45                          | 1,024            | 4,28             | 52,24            | 24,04                          | 3,39 | 0,1386 | 1,27                | 0,29                             | 237 | 162 | 174 | 158 | 169 | 97  | 54   | 830 | 200 | 149  |
| BZY390   | 1,19 | 11,58                          | 1,037            | 4,18             | 52,42            | 24,37                          | 3,43 | 0,1412 | 1,04                | 0,33                             | 238 | 164 | 178 | 161 | 166 | 102 | 101  | 834 | 204 | 167  |
| BZY370   | 1,48 | 11,40                          | 1,033            | 4,26             | 52,28            | 24,08                          | 3,45 | 0,1363 | 1,20                | 0,28                             | 238 | 162 | 177 | 154 | 169 | 93  | 74   | 811 | 212 | 165  |
| BZY298   | 1,63 | 11,60                          | 1,018            | 4,39             | 52,07            | 24,08                          | 3,54 | 0,1377 | 0,95                | 0,32                             | 235 | 169 | 172 | 155 | 167 | 94  | 58   | 816 | 200 | 138  |
| BZY388   | 1,06 | 11,37                          | 1,022            | 4,45             | 52,68            | 23,93                          | 3,54 | 0,1324 | 1,30                | 0,26                             | 226 | 155 | 172 | 153 | 179 | 93  | 86   | 783 | 206 | 156  |
| BZY392   | 1,56 | 11,58                          | 1,005            | 4,32             | 51,52            | 24,26                          | 3,56 | 0,1291 | 1,23                | 0,50                             | 222 | 174 | 175 | 162 | 164 | 91  | 59   | 802 | 213 | 163  |
| BZY367   | 1,35 | 11,82                          | 1,011            | 4,13             | 51,59            | 24,26                          | 3,75 | 0,1451 | 1,40                | 0,25                             | 224 | 158 | 177 | 160 | 196 | 113 | 85   | 784 | 211 | 154  |
| BZY363   | 1,32 | 10,74                          | 1,039            | 4,34             | 53,38            | 23,70                          | 3,27 | 0,1270 | 1,23                | 0,26                             | 249 | 167 | 176 | 151 | 165 | 84  | 75   | 827 | 204 | 135  |
| BZY387   | 1,44 | 10,96                          | 1,026            | 4,23             | 53,01            | 23,72                          | 3,37 | 0,1320 | 1,39                | 0,26                             | 250 | 171 | 174 | 152 | 161 | 80  | 101  | 827 | 206 | 151  |
| BZY368   | 1,12 | 11,00                          | 1,035            | 4,45             | 53,07            | 23,98                          | 3,40 | 0,1301 | 1,25                | 0,26                             | 240 | 165 | 175 | 155 | 158 | 83  | 73   | 827 | 208 | 155  |
| BZY393   | 1,67 | 11,14                          | 1,031            | 4,23             | 52,70            | 23,61                          | 3,53 | 0,1332 | 1,43                | 0,27                             | 242 | 171 | 173 | 153 | 168 | 99  | 89   | 817 | 197 | 153  |
| BZY381   | 1,19 | 10,62                          | 1,029            | 4,37             | 53,63            | 23,24                          | 3,52 | 0,1261 | 1,72                | 0,24                             | 244 | 163 | 173 | 147 | 169 | 91  | 77   | 796 | 197 | 141  |
| BZY362   | 1,25 | 11,39                          | 1,042            | 4,32             | 52,60            | 24,05                          | 3,44 | 0,1195 | 1,23                | 0,30                             | 240 | 167 | 175 | 155 | 163 | 89  | 87   | 819 | 204 | 153  |
| BYZ430   | 1,45 | 11,05                          | 1,036            | 4,19             | 52,55            | 24,07                          | 3,36 | 0,1312 | 1,43                | 0,26                             | 235 | 168 | 178 | 154 | 164 | 108 | 72   | 916 | 203 | 143  |
| BYZ433   | 2,39 | 10,64                          | 1,031            | 4,30             | 52,65            | 23,48                          | 3,30 | 0,1299 | 1,51                | 0,30                             | 258 | 168 | 182 | 144 | 167 | 106 | 77   | 932 | 194 | 139  |
| BYZ438   | 1,44 | 11,05                          | 1,049            | 4,33             | 52,60            | 24,20                          | 3,25 | 0,1142 | 1,42                | 0,27                             | 257 | 169 | 185 | 158 | 159 | 98  | 71   | 929 | 194 | 142  |
| BZY386   | 1,31 | 10,61                          | 1,043            | 4,24             | 54,10            | 23,38                          | 3,27 | 0,1203 | 1,35                | 0,29                             | 260 | 173 | 174 | 148 | 151 | 82  | 63   | 792 | 208 | 161  |
| BZY394   | 1,19 | 10,31                          | 1,032            | 4,23             | 54,87            | 23,09                          | 3,12 | 0,1213 | 1,41                | 0,27                             | 269 | 164 | 172 | 147 | 150 | 81  | 59   | 764 | 200 | 163  |
| BZY380   | 1,15 | 10,54                          | 1,027            | 4,19             | 54,26            | 23,05                          | 3,70 | 0,1082 | 1,38                | 0,24                             | 248 | 162 | 172 | 146 | 188 | 112 | 73   | 798 | 211 | 139  |

| id.      | CaO         | Fe <sub>2</sub> O <sub>3</sub> | TiO <sub>2</sub> | K <sub>2</sub> O | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | MgO         | MnO           | (Na <sub>2</sub> O) (P <sub>2</sub> O <sub>5</sub> ) | Zr          | Sr         | Rb         | Zn         | Cr         | Ni         | (La)       | Ba        | V          | (Ce)       |            |
|----------|-------------|--------------------------------|------------------|------------------|------------------|--------------------------------|-------------|---------------|--|-------------|------------|------------|------------|------------|------------|------------|-----------|------------|------------|------------|
| BYZ429   | 1,35        | 11,07                          | 1,019            | 4,14             | 51,25            | 24,48                          | 3,29        | 0,1297        | 1,33   | 0,27        | 212        | 149        | *134       | 149        | 161        | 88         | 70        | 898        | 201        | 154        |
| BYZ436   | 1,48        | 10,96                          | 1,039            | 4,39             | 52,58            | 23,83                          | 3,52        | 0,0902        | 1,46   | 0,30        | 252        | 168        | 176        | 154        | 179        | 126        | 80        | 922        | 203        | 141        |
| BYZ448   | 2,03        | 11,15                          | 1,013            | 4,14             | 52,01            | 23,62                          | 3,77        | 0,1159        | 1,36   | 0,47        | 239        | 208        | 180        | 156        | 222        | 144        | 76        | 998        | 215        | 134        |
| BZY333   | 1,54        | 11,17                          | 1,007            | 4,00             | 53,30            | 23,11                          | 4,08        | 0,1517        | 1,06   | 0,29        | 214        | 155        | 162        | 150        | 215        | 150        | 72        | 746        | 200        | 116        |
| BZY379   | 1,45        | 11,07                          | 1,019            | 3,94             | 53,37            | 23,14                          | 4,13        | 0,1562        | 1,16   | 0,26        | 206        | 155        | 162        | 145        | 216        | 149        | 55        | 756        | 203        | 162        |
| BZY378   | 1,25        | 11,16                          | 1,032            | 3,98             | 53,28            | 23,42                          | 4,06        | 0,1510        | 1,14   | 0,29        | 207        | 152        | 168        | 150        | 207        | 148        | 70        | 746        | 207        | 134        |
| BZY287   | 1,59        | 11,16                          | 1,005            | 4,01             | 53,11            | 23,12                          | 4,15        | 0,1456        | 1,08   | 0,28        | 204        | 154        | 160        | 146        | 226        | 167        | 71        | 723        | 204        | 129        |
| BZY288   | 1,46        | 11,28                          | 1,012            | 4,00             | 53,24            | 23,22                          | 4,08        | 0,1647        | 1,01   | 0,28        | 210        | 157        | 161        | 145        | 220        | 144        | 63        | 760        | 195        | 116        |
| BZY335   | 2,80        | 11,03                          | 0,988            | 4,04             | 52,50            | 22,77                          | 4,21        | 0,1567        | 0,99   | 0,27        | 207        | 163        | 158        | 150        | 224        | 153        | 55        | 742        | 189        | 145        |
| BZY285   | 1,55        | 10,77                          | 0,996            | 4,09             | 53,65            | 22,55                          | 4,44        | 0,1561        | 1,09   | 0,27        | 220        | 153        | 159        | 152        | 246        | 152        | 64        | 729        | 197        | 121        |
| BZY286   | 1,60        | 10,68                          | 0,990            | 4,34             | 53,28            | 22,46                          | 4,44        | 0,1589        | 1,41   | 0,26        | 224        | 151        | 159        | 145        | 242        | 160        | 66        | 717        | 209        | 129        |
| BZY397   | 1,99        | 11,32                          | 0,999            | 4,13             | 52,08            | 23,25                          | 4,10        | 0,1367        | 1,34   | 0,29        | 225        | 158        | 165        | 150        | 214        | 138        | 54        | 788        | 203        | 138        |
| BZY334   | 1,66        | 10,81                          | 0,980            | 4,13             | 53,19            | 23,00                          | 3,98        | 0,1306        | 1,52   | 0,29        | 203        | 161        | 160        | 153        | 201        | 136        | 63        | 731        | 197        | 127        |
| BZY284   | 1,46        | 10,84                          | 1,000            | 4,59             | 53,14            | 23,03                          | 3,76        | 0,1683        | 1,37   | 0,27        | 225        | 162        | 159        | 145        | 198        | 115        | 57        | 784        | 195        | 139        |
| BZY331   | 1,40        | 11,11                          | 1,016            | 4,19             | 53,40            | 23,11                          | 3,87        | 0,1613        | 1,17   | 0,31        | 217        | 162        | 163        | 143        | 196        | 121        | 52        | 777        | 188        | 125        |
| BZY332   | 1,75        | 10,88                          | 0,969            | 4,86             | 53,36            | 22,31                          | 4,02        | 0,1426        | 1,21   | 0,26        | 200        | 164        | 164        | 139        | 212        | 148        | 72        | 754        | 203        | 126        |
| BYZ437   | 1,46        | 11,56                          | 1,032            | 4,40             | 51,25            | 24,04                          | 4,08        | 0,1457        | 1,46   | 0,29        | 236        | 157        | 181        | 161        | 218        | 156        | 76        | 875        | 218        | 153        |
| BZY291   | 1,65        | 12,71                          | 1,045            | 4,09             | 51,09            | 23,91                          | 3,68        | 0,1578        | 1,10   | 0,30        | 183        | 157        | 176        | 156        | 164        | 105        | 62        | 828        | 202        | 130        |
| BZY295   | 1,14        | 12,22                          | 1,002            | 3,99             | 52,88            | 23,33                          | 3,55        | 0,1350        | 1,20   | 0,31        | 182        | 152        | 169        | 159        | 166        | 103        | 76        | 757        | 187        | 129        |
| <b>m</b> | <b>1,50</b> | <b>11,19</b>                   | <b>1,020</b>     | <b>4,24</b>      | <b>52,72</b>     | <b>23,59</b>                   | <b>3,68</b> | <b>0,1374</b> | <b>1,27</b>  | <b>0,29</b> | <b>228</b> | <b>163</b> | <b>171</b> | <b>152</b> | <b>185</b> | <b>114</b> | <b>71</b> | <b>810</b> | <b>203</b> | <b>144</b> |
| <b>σ</b> | <b>0,33</b> | <b>0,47</b>                    | <b>0,019</b>     | <b>0,18</b>      | <b>0,85</b>      | <b>0,57</b>                    | <b>0,35</b> | <b>0,0162</b> | <b>0,17</b>  | <b>0,05</b> | <b>20</b>  | <b>10</b>  | <b>8</b>   | <b>6</b>   | <b>27</b>  | <b>13</b>  | <b>64</b> | <b>8</b>   | <b>14</b>  |            |
| BZY299   | 5,58        | 9,83                           | 0,891            | 3,73             | 52,23            | 21,44                          | 4,57        | 0,1348        | 0,88   | 0,30        | 198        | 191        | 160        | 137        | 264        | 212        | 62        | 639        | 177        | 109        |
| BYZ886   | 6,70        | 9,39                           | 0,878            | 3,69             | 52,18            | 21,76                          | 3,32        | 0,1309        | 1,46   | 0,26        | 222        | 189        | 172        | 123        | 183        | 137        | 52        | 803        | 166        | 122        |
| BYZ449   | 1,64        | 9,85                           | 1,101            | 3,63             | 56,28            | 22,19                          | 2,96        | 0,1000        | 1,44   | 0,28        | 255        | 149        | 148        | 132        | 169        | 118        | 67        | 670        | 196        | 124        |
| BZY369   | 1,84        | 9,52                           | 1,036            | 3,55             | 57,32            | 21,35                          | 3,18        | 0,0961        | 1,64   | 0,24        | 258        | 179        | 151        | 127        | 169        | 98         | 56        | 633        | 184        | 123        |

| id.  | CaO   | Fe <sub>2</sub> O <sub>3</sub> | TiO <sub>2</sub> | K <sub>2</sub> O | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | MgO  | MnO    | (Na <sub>2</sub> O) (P <sub>2</sub> O <sub>5</sub> ) | Zr   | Sr  | Rb  | Zn  | Cr  | Ni  | (La) | Ba   | V   | (Ce) |      |
|--|-------|--------------------------------|------------------|------------------|------------------|--------------------------------|------|--------|--|------|-----|-----|-----|-----|-----|------|------|-----|------|------|
| BYZ883   | 1,42  | 9,51                           | 1,169            | 2,37             | 59,04            | 22,20                          | 2,66 | 0,1903 | 1,09   | 0,14 | 256 | 109 | 143 | 183 | 268 | 225  | 50   | 554 | 157  | 115  |
| <b>mixed group, including Schneider's "Graue Platten" attributed to Ephesos and Byzantine/early Turkish common wares</b> |       |                                |                  |                  |                  |                                |      |        |  |      |     |     |     |     |     |      |      |     |      |      |
| BPH206   | 10,08 | 7,39                           | 0,698            | 3,66             | 55,21            | 18,87                          | 2,90 | 0,1030 | 0,66   | 0,40 | 164 | 182 | 191 | 109 | 204 | 156  | 42   | 623 | 128  | 70   |
| EPH205   | 10,07 | 7,41                           | 0,711            | 3,61             | 55,17            | 18,96                          | 2,85 | 0,1050 | 0,65   | 0,44 | 160 | 201 | 186 | 105 | 204 | 151  | 39   | 671 | 127  | 82   |
| BPH207   | 8,65  | 7,68                           | 0,731            | 3,72             | 55,11            | 19,71                          | 2,96 | 0,1070 | 0,67   | 0,66 | 169 | 177 | 187 | 112 | 218 | 156  | 52   | 596 | 150  | 91   |
| GSB206   | 12,50 | 7,36                           | 0,713            | 3,29             | 52,12            | 19,00                          | 3,02 | 0,1080 | 0,52   | 1,34 | 166 | 186 | 177 | 110 | 210 | 168  | 52   | 641 | 132  | 95   |
| BPH208   | 9,97  | 7,47                           | 0,715            | 3,58             | 55,13            | 19,19                          | 2,88 | 0,1230 | 0,55   | 0,39 | 174 | 214 | 178 | 99  | 209 | 161  | 44   | 632 | 127  | 97   |
| EPH212   | 10,68 | 7,30                           | 0,709            | 3,51             | 55,17            | 18,80                          | 2,74 | 0,1200 | 0,59   | 0,35 | 179 | 226 | 175 | 96  | 207 | 165  | 54   | 577 | 125  | 82   |
| BPH210   | 9,59  | 7,57                           | 0,718            | 3,61             | 55,03            | 19,20                          | 3,17 | 0,1160 | 0,54   | 0,45 | 164 | 205 | 177 | 101 | 217 | 168  | 41   | 657 | 131  | <ldd |
| EPH217   | 11,15 | 7,24                           | 0,703            | 3,45             | 54,81            | 18,20                          | 3,10 | 0,1250 | 0,83   | 0,38 | 173 | 235 | 156 | 103 | 213 | 169  | 44   | 614 | 124  | 70   |
| EPH215   | 12,18 | 7,14                           | 0,700            | 3,38             | 54,14            | 18,30                          | 3,07 | 0,1150 | 0,57   | 0,38 | 174 | 194 | 168 | 103 | 213 | 162  | 50   | 545 | 129  | 99   |
| EPH216   | 11,48 | 6,92                           | 0,702            | 3,24             | 55,88            | 17,72                          | 2,96 | 0,1160 | 0,57   | 0,38 | 187 | 170 | 159 | 91  | 202 | 155  | 45   | 513 | 125  | 95   |
| GSM 65   | 10,48 | 7,47                           | 0,740            | 3,38             | 55,65            | 18,31                          | 3,00 | 0,1300 | 0,45   | 0,85 | 159 | 160 | 165 | 109 | 224 | 129  | <ldd | 503 | <ldd | <ldd |
| BZY400   | 12,51 | 6,63                           | 0,694            | 3,88             | 51,70            | 19,60                          | 3,69 | 0,1126 | 0,48   | 0,50 | 171 | 207 | 172 | 111 | 186 | 148  | 64   | 639 | 139  | 118  |
| EPH213   | 11,37 | 8,30                           | 0,681            | 3,59             | 51,94            | 18,90                          | 3,34 | 0,1040 | 0,58   | 1,15 | 150 | 207 | 188 | 115 | 206 | 168  | 40   | 501 | 142  | 71   |
| GSB497   | 11,62 | 7,79                           | 0,741            | 3,51             | 51,78            | 19,21                          | 3,35 | 0,1160 | 0,51   | 1,36 | 174 | 153 | 172 | 127 | 222 | 173  | 72   | 728 | 119  | 88   |
| BZY407   | 15,35 | 6,50                           | 0,692            | 3,81             | 50,61            | 19,10                          | 2,79 | 0,1074 | 0,38   | 0,44 | 168 | 186 | 163 | 107 | 191 | 148  | 64   | 666 | 154  | 98   |
| BZY406   | 16,72 | 6,61                           | 0,696            | 3,73             | 49,47            | 18,41                          | 3,06 | 0,1125 | 0,32   | 0,65 | 160 | 195 | 155 | 112 | 211 | 152  | 72   | 596 | 149  | 79   |
| BZY405   | 13,70 | 6,53                           | 0,694            | 3,95             | 50,55            | 20,18                          | 3,24 | 0,0826 | 0,36   | 0,52 | 167 | 187 | 169 | 100 | 181 | 134  | 52   | 667 | 159  | 122  |
| BZY404   | 12,29 | 7,08                           | 0,726            | 3,97             | 51,70            | 20,05                          | 2,94 | 0,0937 | 0,38   | 0,55 | 182 | 179 | 111 | 208 | 152 | <ldd | 683  | 163 | 128  |      |
| GSB210   | 11,58 | 7,35                           | 0,714            | 3,18             | 52,89            | 18,51                          | 4,76 | 0,1140 | 0,57   | 0,32 | 171 | 166 | 153 | 99  | 204 | 176  | 56   | 462 | 125  | 84   |
| GSB209   | 11,87 | 7,21                           | 0,702            | 3,17             | 52,73            | 18,30                          | 4,98 | 0,1140 | 0,51   | 0,40 | 168 | 158 | 151 | 93  | 210 | 165  | 36   | 436 | 134  | 82   |
| GSB208   | 9,53  | 7,63                           | 0,740            | 3,01             | 54,66            | 19,05                          | 4,16 | 0,1190 | 0,69   | 0,39 | 181 | 165 | 152 | 101 | 236 | 183  | 41   | 483 | 134  | 99   |
| GSB205   | 12,24 | 7,50                           | 0,714            | 3,30             | 52,47            | 18,93                          | 4,00 | 0,1140 | 0,44   | 0,28 | 161 | 147 | 174 | 98  | 216 | 167  | 29   | 464 | 136  | 72   |
| EPH214   | 10,93 | 7,15                           | 0,690            | 3,39             | 54,30            | 18,30                          | 4,07 | 0,1280 | 0,61   | 0,40 | 173 | 219 | 163 | 100 | 202 | 158  | 29   | 536 | 117  | 77   |
| BZY383   | 13,40 | 6,36                           | 0,719            | 3,26             | 53,59            | 16,44                          | 4,63 | 0,1167 | 0,95   | 0,31 | 170 | 151 | 93  | 200 | 166 | 36   | 579  | 108 | 85   |      |

| id.      | CaO          | Fe <sub>2</sub> O <sub>3</sub> | TiO <sub>2</sub> | K <sub>2</sub> O | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | MgO         | MnO           | (Na <sub>2</sub> O) (P <sub>2</sub> O <sub>5</sub> ) | Zr          | Sr         | Rb         | Zn         | Cr         | Ni         | (La)       | Ba        | V          | (Ce)       |           |
|----------|--------------|--------------------------------|------------------|------------------|------------------|--------------------------------|-------------|---------------|--|-------------|------------|------------|------------|------------|------------|------------|-----------|------------|------------|-----------|
| <b>m</b> | <b>11,66</b> | <b>7,23</b>                    | <b>0,710</b>     | <b>3,51</b>      | <b>53,41</b>     | <b>18,80</b>                   | <b>3,40</b> | <b>0,1126</b> | <b>0,56</b>  | <b>0,55</b> | <b>169</b> | <b>190</b> | <b>169</b> | <b>104</b> | <b>208</b> | <b>160</b> | <b>48</b> | <b>584</b> | <b>134</b> | <b>90</b> |
| <b>σ</b> | <b>1,84</b>  | <b>0,46</b>                    | <b>0,017</b>     | <b>0,26</b>      | <b>1,86</b>      | <b>0,78</b>                    | <b>0,67</b> | <b>0,0105</b> | <b>0,14</b>  | <b>0,31</b> | <b>8</b>   | <b>26</b>  | <b>12</b>  | <b>8</b>   | <b>12</b>  | <b>12</b>  | <b>81</b> | <b>14</b>  | <b>16</b>  |           |
| BZY401   | 15,33        | 6,31                           | 0,731            | 3,06             | 54,67            | 15,90                          | 2,68        | 0,0957        | 0,61   | 0,39        | 170        | 221        | 143        | 111        | 269        | 314        | 42        | 510        | 143        | 106       |
| BZY408   | 18,39        | 5,36                           | 0,617            | 3,88             | 50,49            | 17,54                          | 2,30        | 0,0810        | 0,65   | 0,48        | 182        | 193        | 166        | 97         | 144        | 99         | 40        | 644        | 135        | 95        |
| BZY316   | 10,51        | 8,36                           | 0,957            | 3,03             | 56,13            | 17,83                          | 1,84        | 0,1496        | 0,64   | 0,33        | 182        | 159        | 132        | 112        | 263        | 224        | <ldd      | 602        | 135        | 78        |
| BZY323   | 9,19         | 7,99                           | 0,935            | 3,13             | 56,87            | 18,08                          | 2,57        | 0,1319        | 0,61   | 0,26        | 184        | 179        | 140        | 105        | 295        | 244        | <ldd      | 469        | 150        | 79        |
| GSB207   | 10,55        | 7,41                           | 0,710            | 5,47             | 51,68            | 18,76                          | 3,70        | 0,1490        | 0,93   | 0,62        | 166        | 180        | 212        | 100        | 213        | 165        | 33        | 875        | 126        | 81        |
| BZY399   | 13,39        | 7,11                           | 0,828            | 3,23             | 50,50            | 19,94                          | 2,89        | 0,0848        | 0,92   | 0,88        | 277        | 226        | 121        | 126        | 143        | 95         | 61        | 756        | 150        | 140       |
| BZY398   | 10,90        | 7,80                           | 0,783            | 3,82             | 50,57            | 20,88                          | 3,36        | 0,0938        | 1,01   | 0,53        | 239        | 284        | 154        | 134        | 173        | 94         | 39        | 926        | 184        | 149       |
| BZY384   | 11,60        | 7,77                           | 1,046            | 3,51             | 51,41            | 19,71                          | 3,20        | 0,1294        | 1,09   | 0,29        | 213        | 250        | 158        | 110        | 173        | 108        | 61        | 583        | 143        | 106       |

**local group b/2, early Turkish table wares**

|        |      |      |       |      |       |       |      |        |      |      |     |     |     |     |     |     |    |     |     |     |
|--------|------|------|-------|------|-------|-------|------|--------|------|------|-----|-----|-----|-----|-----|-----|----|-----|-----|-----|
| BZY366 | 4,36 | 8,37 | 0,902 | 3,75 | 56,21 | 20,03 | 4,40 | 0,1030 | 1,13 | 0,21 | 161 | 254 | 174 | 120 | 221 | 293 | 41 | 661 | 144 | 128 |
| BZY371 | 4,41 | 8,36 | 0,927 | 3,79 | 56,44 | 20,12 | 4,21 | 0,1006 | 1,07 | 0,19 | 173 | 251 | 170 | 115 | 225 | 280 | 55 | 654 | 143 | 108 |
| BYZ442 | 4,01 | 8,33 | 0,968 | 3,59 | 57,70 | 19,69 | 3,93 | 0,0928 | 1,22 | 0,23 | 177 | 252 | 171 | 119 | 214 | 319 | 55 | 677 | 135 | 115 |
| BYZ441 | 4,95 | 8,33 | 0,915 | 3,88 | 55,57 | 20,25 | 3,84 | 0,1043 | 1,45 | 0,47 | 162 | 228 | 162 | 129 | 199 | 277 | 53 | 756 | 142 | 121 |
| BZY382 | 3,46 | 8,67 | 1,010 | 4,10 | 55,10 | 21,79 | 3,90 | 0,1043 | 1,19 | 0,22 | 178 | 280 | 186 | 126 | 191 | 205 | 63 | 724 | 149 | 123 |
| BZY385 | 3,69 | 8,47 | 0,991 | 4,07 | 55,34 | 21,46 | 4,12 | 0,0948 | 1,28 | 0,21 | 180 | 291 | 189 | 123 | 184 | 220 | 70 | 713 | 147 | 148 |
| BZY372 | 3,17 | 8,46 | 0,974 | 4,04 | 56,39 | 21,33 | 3,77 | 0,0963 | 1,24 | 0,26 | 171 | 254 | 184 | 114 | 201 | 234 | 54 | 712 | 138 | 125 |
| BYZ432 | 3,78 | 8,39 | 0,961 | 3,90 | 56,27 | 20,68 | 4,03 | 0,0986 | 1,35 | 0,24 | 180 | 261 | 183 | 124 | 209 | 291 | 62 | 738 | 142 | 122 |
| BYZ435 | 4,72 | 8,37 | 0,934 | 4,25 | 54,97 | 20,74 | 3,99 | 0,1015 | 1,29 | 0,29 | 169 | 275 | 183 | 125 | 218 | 294 | 59 | 724 | 136 | 119 |
| BYZ428 | 4,24 | 8,58 | 0,977 | 3,90 | 54,81 | 21,35 | 4,22 | 0,0967 | 1,35 | 0,21 | 169 | 275 | 195 | 124 | 208 | 280 | 61 | 723 | 140 | 125 |
| BYZ431 | 4,22 | 8,59 | 0,973 | 4,00 | 54,98 | 21,03 | 4,19 | 0,1001 | 1,34 | 0,27 | 175 | 262 | 188 | 140 | 220 | 301 | 54 | 795 | 138 | 124 |
| BZY365 | 2,77 | 8,44 | 1,028 | 4,04 | 55,95 | 22,20 | 3,42 | 0,0981 | 1,33 | 0,21 | 189 | 268 | 190 | 121 | 159 | 149 | 98 | 679 | 145 | 131 |
| BZY377 | 2,49 | 8,20 | 0,999 | 4,04 | 57,22 | 21,57 | 3,40 | 0,0956 | 1,46 | 0,22 | 193 | 268 | 183 | 118 | 158 | 156 | 88 | 708 | 148 | 129 |
| BZY373 | 3,14 | 8,16 | 0,981 | 3,86 | 57,81 | 20,57 | 3,52 | 0,0911 | 1,35 | 0,22 | 188 | 251 | 175 | 115 | 172 | 198 | 51 | 710 | 149 | 128 |

| id.   | CaO         | Fe <sub>2</sub> O <sub>3</sub> | TiO <sub>2</sub> | K <sub>2</sub> O | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | MgO         | MnO           | (Na <sub>2</sub> O) | (P <sub>2</sub> O <sub>5</sub> ) | Zr         | Sr         | Rb         | Zn         | Cr         | Ni         | (La)      | Ba         | V          | (Ce)       |
|---|-------------|--------------------------------|------------------|------------------|------------------|--------------------------------|-------------|---------------|---------------------|----------------------------------|------------|------------|------------|------------|------------|------------|-----------|------------|------------|------------|
| BYZ447  | 6,14        | 8,15                           | 0,960            | 3,93             | 54,36            | 20,74                          | 3,53        | 0,0926        | 1,31                | 0,24                             | 180        | 279        | 171        | 121        | 196        | 208        | 63        | 764        | 134        | 116        |
| BYZ440  | 3,32        | 8,29                           | 1,024            | 4,21             | 55,53            | 21,98                          | 3,58        | 0,0929        | 1,49                | 0,23                             | 195        | 340        | 196        | 125        | 159        | 182        | 62        | 835        | 137        | 127        |
| BYZ434  | 3,42        | 9,01                           | 1,013            | 4,40             | 54,29            | 22,38                          | 3,35        | 0,1113        | 1,46                | 0,28                             | 170        | 248        | 199        | 138        | 204        | 229        | 52        | 778        | 138        | 119        |
| <b>m</b>  | <b>3,90</b> | <b>8,42</b>                    | <b>0,973</b>     | <b>3,99</b>      | <b>55,82</b>     | <b>21,05</b>                   | <b>3,85</b> | <b>0,0985</b> | <b>1,31</b>         | <b>0,25</b>                      | <b>177</b> | <b>267</b> | <b>182</b> | <b>123</b> | <b>196</b> | <b>242</b> | <b>61</b> | <b>727</b> | <b>141</b> | <b>124</b> |
| <b>σ</b>  | <b>0,89</b> | <b>0,21</b>                    | <b>0,037</b>     | <b>0,20</b>      | <b>1,07</b>      | <b>0,79</b>                    | <b>0,33</b> | <b>0,0053</b> | <b>0,12</b>         | <b>0,06</b>                      | <b>10</b>  | <b>24</b>  | <b>10</b>  | <b>7</b>   | <b>23</b>  | <b>54</b>  | <b>14</b> | <b>48</b>  | <b>5</b>   | <b>9</b>   |
| BZY301  | 5,53        | 8,37                           | 0,891            | 4,22             | 54,36            | 20,63                          | 4,62        | 0,0946        | 0,80                | 0,25                             | 175        | 263        | 171        | 132        | 145        | 104        | 53        | 835        | 128        | 126        |
| BZY319  | 4,27        | 8,37                           | 0,918            | 4,46             | 54,42            | 21,18                          | 4,87        | 0,0981        | 0,91                | 0,24                             | 174        | 315        | 182        | 131        | 148        | 95         | 66        | 857        | 145        | 110        |
| BZY289  | 6,36        | 7,89                           | 0,876            | 4,21             | 55,60            | 19,89                          | 3,49        | 0,1055        | 1,02                | 0,27                             | 187        | 287        | 163        | 119        | 129        | 87         | 51        | 857        | 141        | 91         |
| BZY403  | 10,12       | 6,20                           | 0,886            | 2,73             | 57,31            | 18,61                          | 2,82        | 0,0590        | 0,70                | 0,35                             | 290        | 299        | 95         | 107        | 180        | 150        | 66        | 558        | 84         | 111        |
| BYZ439  | 4,70        | 7,47                           | 0,980            | 3,23             | 61,19            | 17,56                          | 2,89        | 0,0894        | 1,40                | 0,27                             | 248        | 226        | 137        | 111        | 155        | 192        | 55        | 661        | 131        | 108        |
| BYZ889  | 18,09       | 7,34                           | 0,864            | 2,16             | 50,82            | 16,71                          | 2,70        | 0,0998        | 0,80                | 0,23                             | 266        | 134        | 110        | 96         | 168        | 120        | 33        | 432        | 144        | 88         |
| BZY402  | 13,48       | 5,33                           | 0,747            | 3,72             | 55,92            | 15,81                          | 3,36        | 0,0749        | 0,88                | 0,45                             | 245        | 443        | 221        | 104        | 160        | 128        | <ldd      | 528        | 136        | 106        |
| local (?) group d, including Byzantine/early Turkish common wares, and late Roman cooking wares |             |                                |                  |                  |                  |                                |             |               |                     |                                  |            |            |            |            |            |            |           |            |            |            |
| BZY395  | 0,90        | 8,82                           | 0,940            | 1,73             | 65,00            | 18,00                          | 2,75        | 0,0841        | 1,52                | 0,08                             | 203        | 57         | 95         | 81         | 365        | 275        | 58        | 286        | 173        | 66         |
| BYZ884  | 2,11        | 7,56                           | 0,913            | 1,70             | 65,63            | 17,29                          | 2,85        | 0,0810        | 1,52                | 0,15                             | 220        | 83         | 92         | 85         | 296        | 275        | 35        | 412        | 150        | 83         |
| BZY396  | 1,28        | 8,58                           | 0,953            | 1,93             | 64,45            | 17,45                          | 3,20        | 0,1030        | 1,54                | 0,33                             | 207        | 76         | 79         | 106        | 363        | 297        | 39        | 376        | 150        | 67         |
| BYZ443  | 2,15        | 9,43                           | 1,082            | 1,62             | 61,42            | 18,81                          | 3,22        | 0,0878        | 1,85                | 0,13                             | 214        | 119        | 85         | 79         | 387        | 331        | 39        | 344        | 181        | 79         |
| BYZ445  | 1,98        | 8,74                           | 1,050            | 2,27             | 61,23            | 18,37                          | 3,59        | 0,1192        | 1,69                | 0,74                             | 222        | 115        | 103        | 104        | 446        | 332        | 37        | 426        | 169        | 76         |
| BYZ967  | 2,41        | 8,23                           | 0,862            | 1,34             | 64,54            | 16,57                          | 4,26        | 0,1054        | 1,27                | 0,22                             | 195        | 84         | 77         | 74         | 416        | 413        | 27        | 325        | 154        | 77         |
| BYZ444  | 1,75        | 9,17                           | 0,999            | 2,27             | 60,58            | 18,44                          | 4,29        | 0,1590        | 1,54                | 0,56                             | 204        | 81         | 98         | 97         | 429        | 409        | 42        | 463        | 162        | 83         |
| BYZ446  | 0,89        | 8,75                           | 1,057            | 2,43             | 63,14            | 20,15                          | 2,17        | 0,1126        | 0,91                | 0,19                             | 271        | 70         | 125        | 105        | 290        | 272        | 50        | 401        | 153        | 105        |
| BYZ968  | 1,23        | 6,81                           | 0,891            | 1,27             | 69,79            | 15,07                          | 3,13        | 0,1314        | 1,42                | 0,08                             | 250        | 57         | 71         | 78         | 271        | 266        | 25        | 287        | 132        | 80         |
| BYZ970  | 1,18        | 6,61                           | 0,838            | 1,36             | 70,99            | 15,65                          | 1,55        | 0,0842        | 1,40                | 0,17                             | 241        | 79         | 63         | 56         | 224        | 230        | 30        | 312        | 124        | 63         |
| BYZ885  | 1,34        | 8,92                           | 0,929            | 1,10             | 63,25            | 17,99                          | 3,80        | 0,1514        | 2,23                | 0,06                             | 215        | 65         | 63         | 66         | 666        | 537        | 39        | 290        | 162        | 90         |
| BYZ969  | 0,98        | 8,91                           | 0,942            | 1,30             | 61,92            | 17,62                          | 4,72        | 0,2375        | 2,93                | 0,12                             | 206        | 90         | 67         | 68         | 643        | 637        | 33        | 211        | 169        | 84         |

samples for local production (kiln furniture, unfinished or overfired wares) could be used to define Pergamene and Ephesian products, on the basis of the chemical composition of ceramic bodies.

Chemical reference groups, corresponding to different periods of production and categories of wares, could be compared. In both Pergamon and Ephesos, several groups may be distinguished, thanks to the varied geological and geochemical features of this region of Western Turkey. They correspond to diverse situations.

Some chemical groups seem fairly well correlated with (large) chronological ranges and categories of wares. Clay procurement may however be diversified, so that a given workshop or workshop complex is characterized by several chemical groups for the same period and types of wares. Some of the groups may however be more representative for the bulk of the production.

Other clay sources continue to be in use for longer periods, with similar traditions in clay pro-

cessing,<sup>51</sup> especially - but not exclusively - in the manufacture of common wares.

In Pergamon for instance, different clayey materials seem to have been used for the main productions of Hellenistic and Roman wares, and of late Byzantine ones. In parallel, part of the pottery was manufactured, presumably in the same workshop or workshops complex, using another clay source common to both periods. In the latter case, chemical data acquired for local wares of a given period may also be used for provenance studies involving the site at another. But this study shows well that, in the general case, caution is requested when using chemical data dealing with wares of different periods, types or categories, involving possibly different traditions in clay processing, and especially in varied geological contexts such as Western Anatolia.

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<sup>51</sup> Clay processing concerns here ceramic bodies, and not surface treatments.

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# Index

- Aegean 35, 77, 92, 110, 119, 154, 157, 159, 176  
Aegean markets 75  
Aegyssus 177  
Africa 78, 159, 177  
African Red Slip (Ware) (ARS) 28, 49, 49 (Fig. 1), 50–53, 57 (Plate 4), 104, 154, 177  
Ağlasun Valley 85  
Aiolis 39  
Aizanoi 177, 179  
Akko region 195  
Akrai 157  
Alexandria 140 n. 51  
Allianoi 176  
Alma Kermen 156  
Anaia 107  
Anemurium 177  
Antandros 176, 176 n. 19  
Antioch 90, 91  
Antioch-on-the-Orontes 175  
Antiocheia 177  
Antikythera 177, 181  
Aolisch Graue Glattware 11 n. 2  
Apamea (Apamée) 23, 46  
Appliqué 7, 11, 13 n. 28, 15, 17 (Fig. 6), 24, 27, 41, 42 (Figs. 3–7), 43, 44, 44 (Fig. 8), 45f, 59–66  
Argos 73 n. 11  
Arretine Sigillata (Arretina) 12, 21  
Artezian 156  
Atarneus 37 (Tab. 2)  
Athens 74 n. 13, 90, 130, 177, 171  
Athenian Agora 44, 73 n. 11, 89, 89 n. 39, 90, 91, 140, 175, 179, 181, 183, 184, 188  
Attica 37 (Tab. 2), 39, 39 (Fig. 6)  
Attalid Kingdom 71  
Asia Minor Sigillata 12  
Asklepieion 20,  
Assos 43, 45, 46, 176  
  
Bakır Gayi 23  
Balıkesir 41, 45  
Bel’bek 156  
Beljaus 141  
Benghazi 73 n. 11, 74 n. 12  
Berenice 177  
Bergama 21 n. 69  
Bird bowl workshop B 39  
  
Blizency 156  
Bonn 15 n 43, 31, 32, 33, 34, 110  
Boscoreale 44  
Bosporan workshop 150  
Bosporan cities 141  
Bosporan Kingdom 129, 130, 149  
Bratskoe cemetery 134, 140  
Brjanskoe 156  
Bulgaria 130  
Bulganak 140  
Burachkov 144 (Fig. 15), 145 (Fig. 16)  
  
Caesarea 156  
Çajka 133, 134 (Fig. 5), 145  
Calabria 78  
Cami Yikiği (Akçapınar Köyü) 95, 96, 99 (Abb. 4), 101 (Abb. 9 + 10), 104 (Abb. 13)  
Campana 168, 169, 170  
Çanakkale 107, 175  
Çanaklı 85, 88  
Çandarlı (= Pitane) 7, 12, 13, 14, 19, 20, 20 (Fig. 12), 21, 23, 28, 29, 36–39, 44, 50, 74, 151, 151 n. 2, 152 (Figs. 1, 2, 3), 153 (Fig. 4), 154, 155 (Figs. 5–6), 156, 157 (Fig. 7), 158 (Fig. 8), 159, 171, 172  
Capernaum 193 n. 16  
Carpathian Mountains 157  
Carvoran 41  
Casa del Menadro 44, 45  
Çatalka 156  
Cayster Valley 75  
Chersonesos 129, 130, 145  
Chios 75  
Chremonidean war 130  
Cimmerian Bosporus 133, 137 (Fig. 9), 156  
Cnidian 168, 168 n. 36  
Constanța 43  
Constantinopole 176  
Copenhagen 45, 46  
Corinth 44, 73 n. 11, 74 n. 12, 77 n. 23, 177  
Crete Island 73 n. 11  
Crimea 7, 130, 133, 141, 156, 172, 177  
Curetes Street 51  
Cypriot-Levantine area 93  
Cypriot Sigillata (Eastern Sigillata D 90, 90 n. 66, 92, 156 “Cypriot Red Slip Ware” (CRS[W])= LR D 95, 96, 97 (Abb. 2), 98 (Abb. 3), 103–105, 193–200

- Cyprus (Chypre) 7, 23, 90, 92, 95, 105, 172, 172 (Fig. 3)  
 Cyrenaica 154, 157, 175, 177
- Danube 176, 177  
 Daskyleion 176, 179  
 Delos 7, 11, 140, 161, 162, 165 n. 26, 170, 171  
 Delos, Aphrodision 163  
 Delos, House of Seals 161, 162 (Fig. 1), 163, 165 n. 26, 166, 167 (Fig. 5), 168, 168 n. 23), 169, 169 n. 39, 169 n. 42, 169 (Tab. 3), 170 (Figs. 6–7, 9), 171  
 Delos, House of Stuccoes 161, 163, 163 (Fig. 2), 164–166, 166 (Fig. 3), 168, 169 n. 40  
 Delos, House of the Sword (Courtyard of) 161, 169 n. 39  
 Delos, Insula of Bronzes 161  
 Delos, Insula of Comedians 161  
 Delos, Insula of Jewels 161  
 Delian 174  
 Dhiorios 23  
 Düzen Tepe 81, 88
- Eastern Sigillata A (ESA) 13 n. 22, 73, 83 (Tab. 1), 89, 90 n. 71–73, 91, 92, 156, 161, 162 (Fig. 1) 164, 164 (Tabs. 1, 2), 164 n. 16, 165, 165 (Tab. 2 ctd), 165 n. 25, 27, 166, 166 (Fig. 3), 167 (Fig. 4), 168, 169, 169 (Tab. 3), 170 (Figs. 6–9)
- Eastern Sigillata B 13, 73, 154, 156
- Eastern Sigillata C (ESC) 13, 15 (Figs. 1–3), 16, 18, 19, 21, 72, 73 n. 10, 74, 74 (Fig. 4–5), 75, 76 (Figs. 8–9), 77 (Figs. 10–12), 78, 79 (Figs. 15–16), 151, 153–159 (Figs. 4–8), 171, 174
- Echt-pergamenische Ware (Sigillata) 13, 14
- Elaia 19, 37, 38 (Table 3), 39, 39 (Fig. 6), 154, 155 (Fig. 6), 159
- Ephesian Red Slip Ware (ERSW) 50–53, 50–52 (Figs. 4–7), 56 (Plate 3:1), 57 (Plate 4), 58 (Plate 5)
- Ephesus (Ephesos) 7, 23, 45, 49, 50–53, 54 (Plate 1), 55 (Plate 2), 59, 60, 61, 62, 63, 64, 71, 72, 75, 88, 89, 90, 91, 91 (n. 77), 92, 107, 107 (n. \*), 110, 112 (tabl. 1), 113, 114 (Fig. 4), 119, 122 (tabl), 125, 129, 141, 171, 174
- Ephesus, church of St. Mary 49, 51
- Ephesus, Episkopeion 51
- Ephesus, Gymnasium of Vediūs 51, 52, 52 (Fig. 6)
- Ephesus, Nymphaeum Traiani 52, 52 (Fig. 7)
- Ephesus, Artemision (Selçuk)
- Ephesus, So-called Tomb of St. Luke 50, 50 (Figs. 3–4), 51 (Fig. 5), 52
- Ephesus, Terrace House 2, Dwelling unit 6 52, 52 (Fig. 8)
- Ephesus, Theatre 51, 52
- Ephesus, Türbe 110, 119
- Evpatoria 134
- Foça (Phokaia) 37 (Tab. 2), 38, 39, 39 (Fig. 6), 50, 159, 177
- Geto-Dacia 133
- Grey Ware 89 n. 38
- Gródek nad Bugiem 157, 158 (Fig. 8), 159
- Gryneion 20, 37, 50
- Halikarnassos 89
- Hama 89, 90
- Hamaxitus, Sanctuary of Apollon Smintheios 77 n. 23
- Hierapolis 95
- Hippos = Susita (Sussita)
- Histria 156
- Iatrus 177, 181
- Ilion 39, 92, 176
- Illuraton 156, 158 (Fig. 8)
- Isa Bey 110
- Italian Sigillata 93, 154
- Ionia 39
- Jebel Khalid 88–92
- Jerash bowl 198 (Pl. 2)
- Kadikalesi 107
- Kadirgürü Mevkisi 95, 96, 100 (Abb. 8), 103, 104 (Abb. 13)
- Kenchreai 45
- Khirbet Karak
- Kiremitli Mevkisi (Haciosmanlar) 95, 96, 102 (Abb. 11), 103, 104 (Abb. 13)
- Knidos 88, 90, 92,
- Komotini 45
- Kömbeci Mevkii 95, 96, 99 (Abb. 5), 100 (Abb. 6), 102 (Abb. 11), 103, 103 (Abb. 12), 104 (Abb. 13)
- Kursi 193
- Kyme 7, 71, 71 n., \*, 72, 72 n. 6, 75, 77, 78, 79
- Late Roman C (LRC)/ Phocaean 7, 20, 20 (Fig. 12), 49–53, 54 (Plate 1), 57 (Plate 4.2), 57 (Plate 5), 75, 78, 79, 159, 177, 193–200, 197–200 (Plates 1–4)
- Late Roman Relief Ware (Oinophorenware) 15, 19, 19 (fig. 10)
- Light Coloured Ware 19, 19 n. 64, 20 (Fig. 20), 175, 176 (Fig. 1), 177
- Llíria 43
- Lokal-pergamenische Ware 13, 13 n. 29,
- Manisa, Kordon Tumulus, 89
- Miletos 34, 34 (Fig. 3), 39
- Meander valley 51, 51 (Fig. 5), 52, 52 (Figs. 6–8), 53, 56 (Plate 3), 57 (Plate 4), 154
- Naukratis 35, 35 (Fig. 5), 36
- Nicea/Iznik 107
- Non-ESC 18 (Fig. 9)
- Oboda 23
- Olbia 45, 129, 130, 131 (Fig. 1, 2), 132 (Fig. 3), 133
- Old Samian (Samien Ancien) 161, 171
- Palaepaphos 92

- Pamphylia (Pamphylien) 96 (Abb. 1), 104  
 Pantikapaion 129, 130, 133, 133 (Fig. 4), 134 (Fig. 5), 140, 142 (Fig. 13), 143 (Fig. 14), 145, 149, 156  
 Paphos 88, 90  
 Parion 155, 156, 158, 159, 175, 177, 179, 183, 185, 191  
 Pednelissos 7, 95, 96  
 Pergamon (city, pottery production centre) *passim*  
 Pergamenian (Group C, Knipovič) 12  
 Pergamenian [part] (Group D, Knipovič) 13  
 Pergamenian [part] (Group E, Knipovič) 13  
 Pergamenian (Sigillata B, Zahn) 12  
 Pergamenische (Pergamenian) Sigillata (Schäfer, Meyer-Schlichtmann) 14, 17 Fig. 7, 18 Fig. 8, 45, 83, 141, 145, 146 Fig. 17, 147 Fig. 18, 149, 151, 154–156, 171  
 Pergamene (as adjective) 7, 13 n. 29, 14, 31, 39, 41, 45, 46, 72, 74, 88 (Fig. 6), 110, 116, 119, 125, 129, 130, 133, 137 (Fig. 9), 140, 141, 145, 149, 150, 151, 155, 156, 161, 164–166, 168–172, 174–175  
 Pergamon, Gate of Philetairos 12  
 Pergamon, Kestel 25, 27, 28, 74, 151  
 Pergamon, Ketios 11, 11 n. 11, 23–25, 27–29, 107, 116, 116 n. 34, 41, 151, 171, 172  
 Pergamon, Red Hall 108 (Fig. 1), 109, 110, 116  
 Phokaia/Gryneion 7  
 Pisidia (Pisidien) 81, 92, 93, 95, 96 (Abb. 1), 104,  
 Pitane cf. Çandarlı  
 Pompeii, Casa del Menandro 44  
 Pontic Sigillata 43  
 Pseudo-Pergamene 161, 166, 169  
 Red-gloss wares of the Pergamon region 14  
 Rotfirniskeramik 14  
 Sagalassos 81–82  
 Sagalassos, Apollo Klarios Temple (AK) 83 (Table 1), 84, 86, 89 n. 35  
 Sagalassos, Eastern Domestic Quarter (TSW5) 83 (Table 1), 84, 89 n. 35  
 Sagalassos, Upper Agora North Terrace (UAN) 82, 83 (Table 1), 84 (Fig. 2)  
 Sagalassos Potters' Quarter 85  
 Sagalassos Red Slip Ware (SRSW) 52, 52 n. 21, 56 (Plate 3:6), 81, 82, 83, (Tab. 1), 85, 87–89, 92, 93, 93 (Fig. 9)  
 Samaria 13  
 Samian (Sigillata A, Zahn) 12, 13, 14, 129  
 Samos 12, 37, 39  
 Sanded Ware 15  
 Sardis 51 n. 14, 88 n. 27, 89, 90, 91 n. 77, 92, 177, 181, 185, 188  
 Sigillata from Meander Valley 51–53, 51–53 (Figs. 5–8), 56 (Plate 3), 57  
 Schitul 43  
 Smyrna 44, 45, 71, 176 (Fig. 1), 177, 179, 188, 191  
 Susita (Sussita)/Hippos 193, , 193 (note \*) 194, 196  
 Tas Silg, Malta 35 (fig. 4)  
 Tel Anafa 89, 90  
 Terra Sigillata Italica 73  
 Theos 39 n. 24  
 Thin-walled ware 44, 89, 163 n. 14  
 Troia Cf Ilion  
 Wardt-Lüttingen 45  
 West Slope (decoration) 15, 16, 17, 72, 73 Figs. 1–2, 88, 130–136 Figs. 1–7, 140  
 White Glazed Ware 52, 52 n. 22, 56 (Plate 3)  
 White-ground Ware 15, 89