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

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

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CERAMIKA STOŁOWA EGEJSKIEGO WYBRZEŻA ANATOLII OD OKRESU PÓŹNOHELLENISTYCZNEGO DO ŚREDNIOWIECZA

PRODUKCJA, NAŚLADOWNICTWA I ZASTOSOWANIE

pod redakcją
HENRYKA MEYZA

przy współpracy
KRZYSZTOFA DOMŻALSKIEGO

WYDAWNICTWO NERITON

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TOME 1

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

THEIR PRODUCTION, IMITATION AND USE

édité par

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avec la collaboration de

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ÉDITIONS NERITON

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PART III: Consumption and distribution

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.[1] 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.:).[2] 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,[3] 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,[4] taking into account more recent analyses carried out in Lyon[5] and in Berlin.[6]

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

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[1] e.g. Böhlendorf-Arslan 2004; *Spätantike und mittelalterliche*; Mania 2006, 475-501; Doğer 20132; *Byzantine craftsmen*; *Türbe*.

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

[3] 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.

[4] 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.

[5] this paper; Waksman forthcoming.

[6] Schneider & Japp 2009, 287-306.

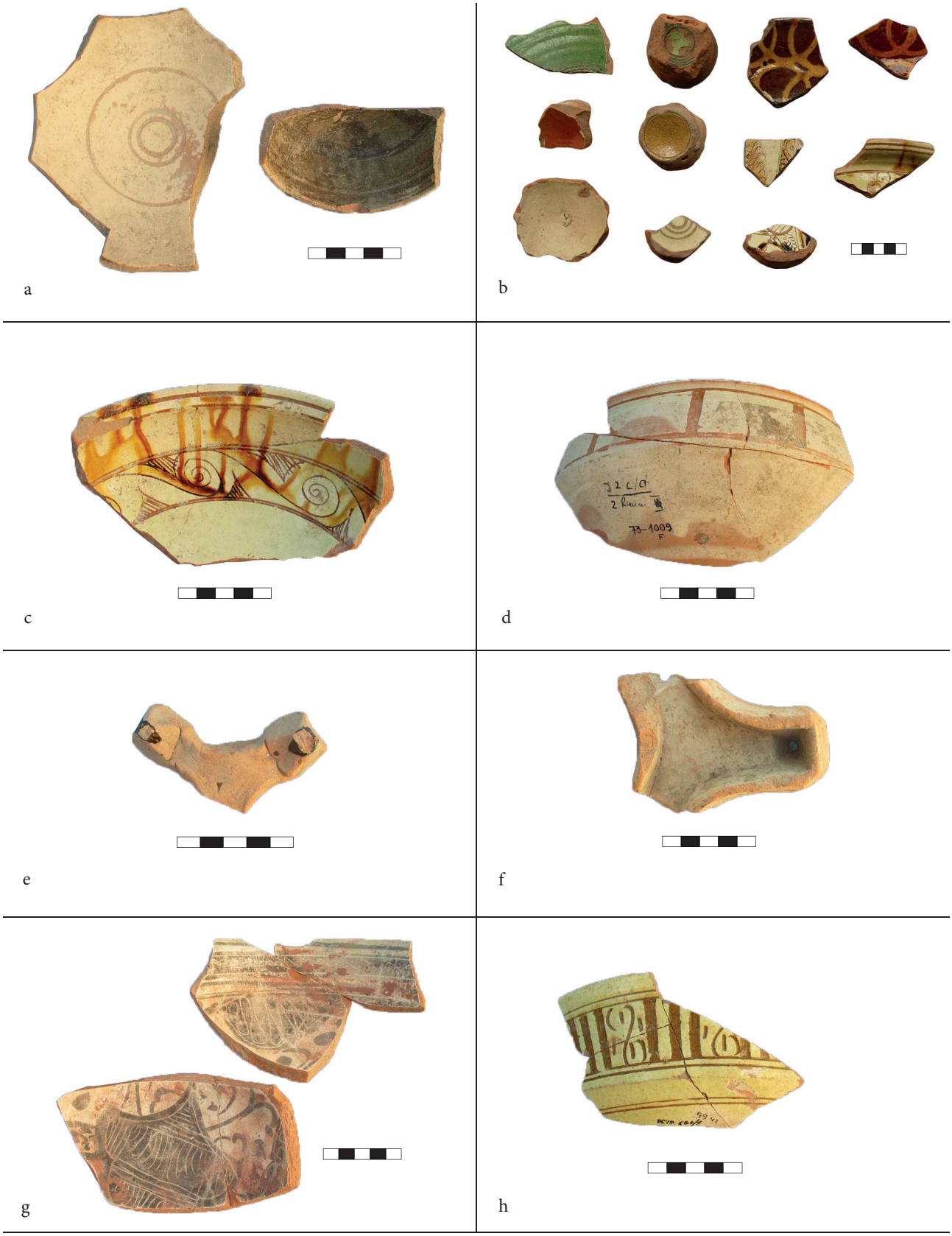

Figure 1: Examples of ceramics analyzed from Pergamon, local references and finished products shown to be local; chemical group B (Byzantine quarters): a-d; chemical group A (Red Hall): e-h (samples numbers given from left to right; pictures S.Y. Waksman); a) biscuit fired wasters (BZY410-411); b) various 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.

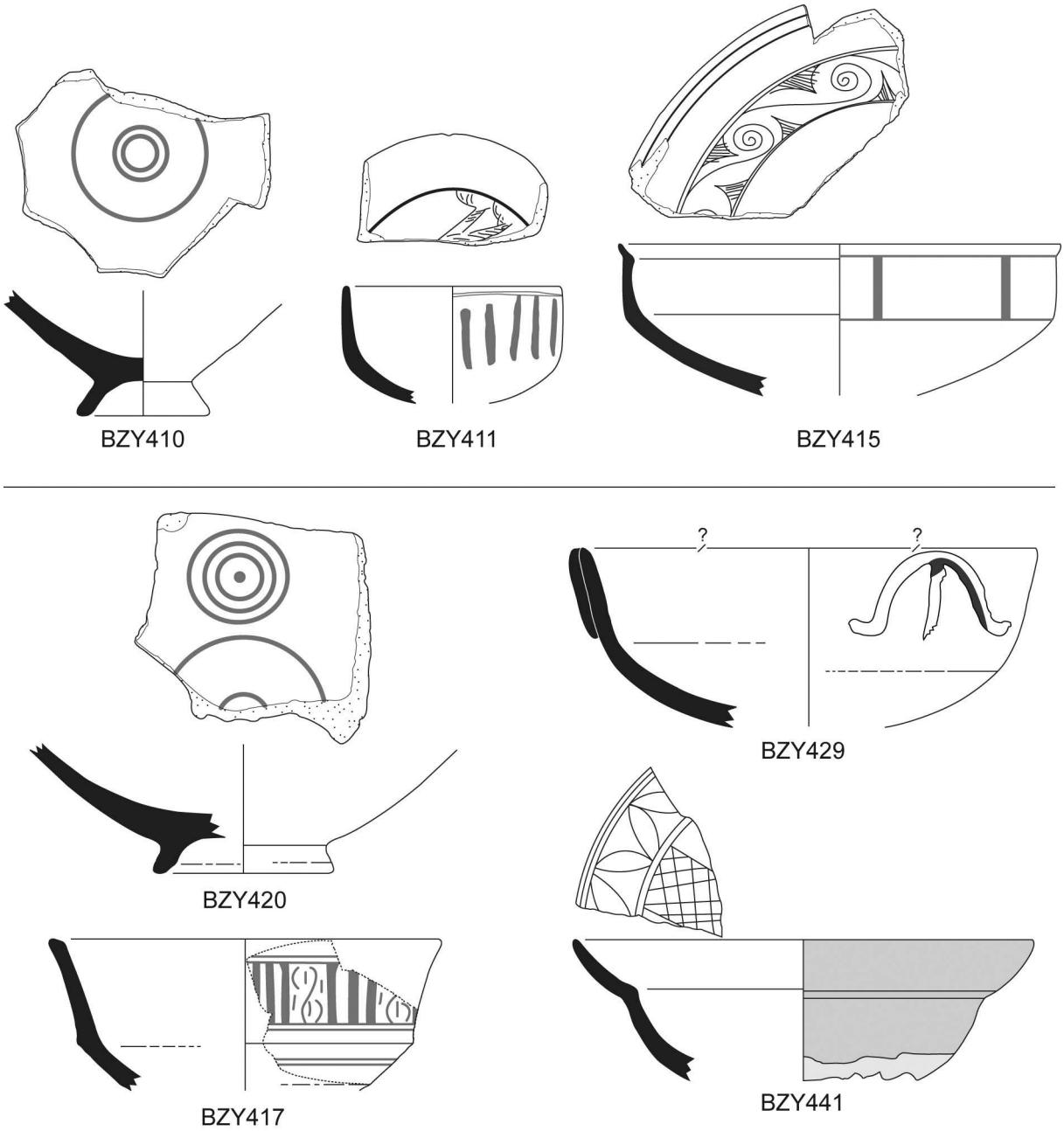

Figure 2: Examples of ceramics analyzed from Pergamon, belonging to local group B (top) and A (bottom) (scale 1/3, S.Y. Waksman, Pergamon team, J. Burlot).

workshops were found;[7] in late Byzantine living quarters on the slopes of the antique city, where fainter but clear evidence is present;[8] 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.[9]

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

[7] Bounegru this volume; Japp 2009, 193-268, for a review of earlier bibliography.

[8] cf. *supra*; Rheidt 1991; Waksman 1995; Spieser 1996; Böhlendorf Arslan 2004; Japp 2010, 862-75.

[9] Mania 2006, 475-501.

[10] Waksman 1995; Waksman *et al.* 1996, 209-18; Waksman & Spieser 1997, 105-33.

[11] Waksman 2006, 563-8.

References 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)[12] 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).[13] Four of the samples taken from the Red Hall contexts were previously selected by S. Japp and analyzed in Bonn and Berlin.[14]

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),[15] 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.[16] Among these groups, constituted in Bonn and Berlin, we used the latter, which are directly comparable to Lyon's.[17] 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 in several locations in the surroundings of the Artemision in Selçuk, a few kilometers away from the antique city of Ephesos.[18] Reference groups had been constituted in Lyon with ceramics coming from ancient excavations in the Artemision and from recent ones in the nearby Türbe.[19] 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), overfired 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);[20]

– moulded wares, both glazed and unglazed, found together with their moulds, attributed to the early Turkish / Beylik period (Fig. 3f, BYZ439-442, BZY373).[21]

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).[22] 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;[23]

– common wares with mica-coated surfaces, dated back to the Byzantine or Turkish period (BYZ443-446, BZY395-396, Fig. 3g);[24]

– 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.[25]

[12] Mania 2006, 490.

[13] Mania 2006, 475-501.

[14] 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.

[15] Waksman 1995; Waksman & Spieser 1997, 105-33.

[16] Japp 2009, 193-268.

[17] Schneider & Japp 2009, 287-306.

[18] Vroom 2005, 17-49; Pfeiffer Taş 2011, 91-154; Parrer forthcoming; Vroom & Fındık forthcoming.

[19] Sauer & Waksman 2005, 51-66; Waksman forthcoming.

[20] Parrer forthcoming; Vroom & Fındık forthcoming.

[21] Vroom 2005, 34-5, type 6; Vroom & Fındık forthcoming.

[22] Vroom 2005, 28-32, types 2 to 5; Waksman forthcoming; Vroom & Fındık forthcoming.

[23] Turnovsky 2005b, 635-45; Waksman & Tréglia 2007, 645-57.

[24] Vroom 2005, 35-6, type 7.

[25] Vroom & Fındık forthcoming.

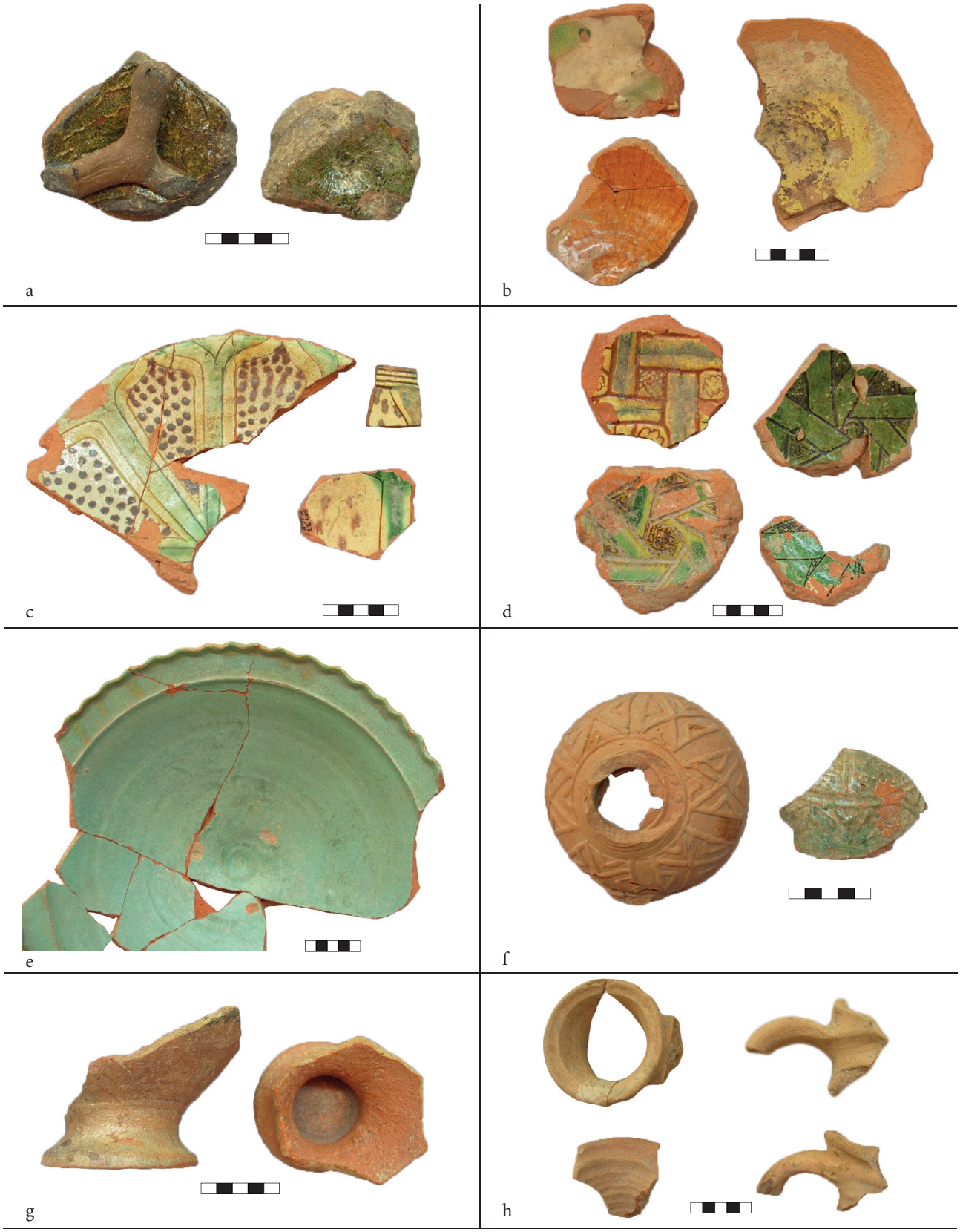

Figure 3: Examples of ceramics analyzed from Ephesos; samples from local groups b/2 and c/4: b-f; other local or possibly local groups: g-h (samples numbers given from left to right, top to bottom; pictures S.Y. Waksman).
a) tripod stilt stuck to a plain glazed base (not sampled); b) plain glazed and 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
Pergamon	
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
Ephesos	
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.[26]

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).[27]

Classifications of the samples are obtained by hierarchical clustering analysis applied to standardized data, using euclidian distance and average linkage.[28] 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

[26] Zabehlicky-Scheffenegger *et al.* 1996, 41-59; Zabehlicky-Scheffenegger & Schneider 2000, 105-12; Schneider 2000, 525-36.

[27] Ce was not taken into account here.

[28] e.g. Picon 1984, 379-99.

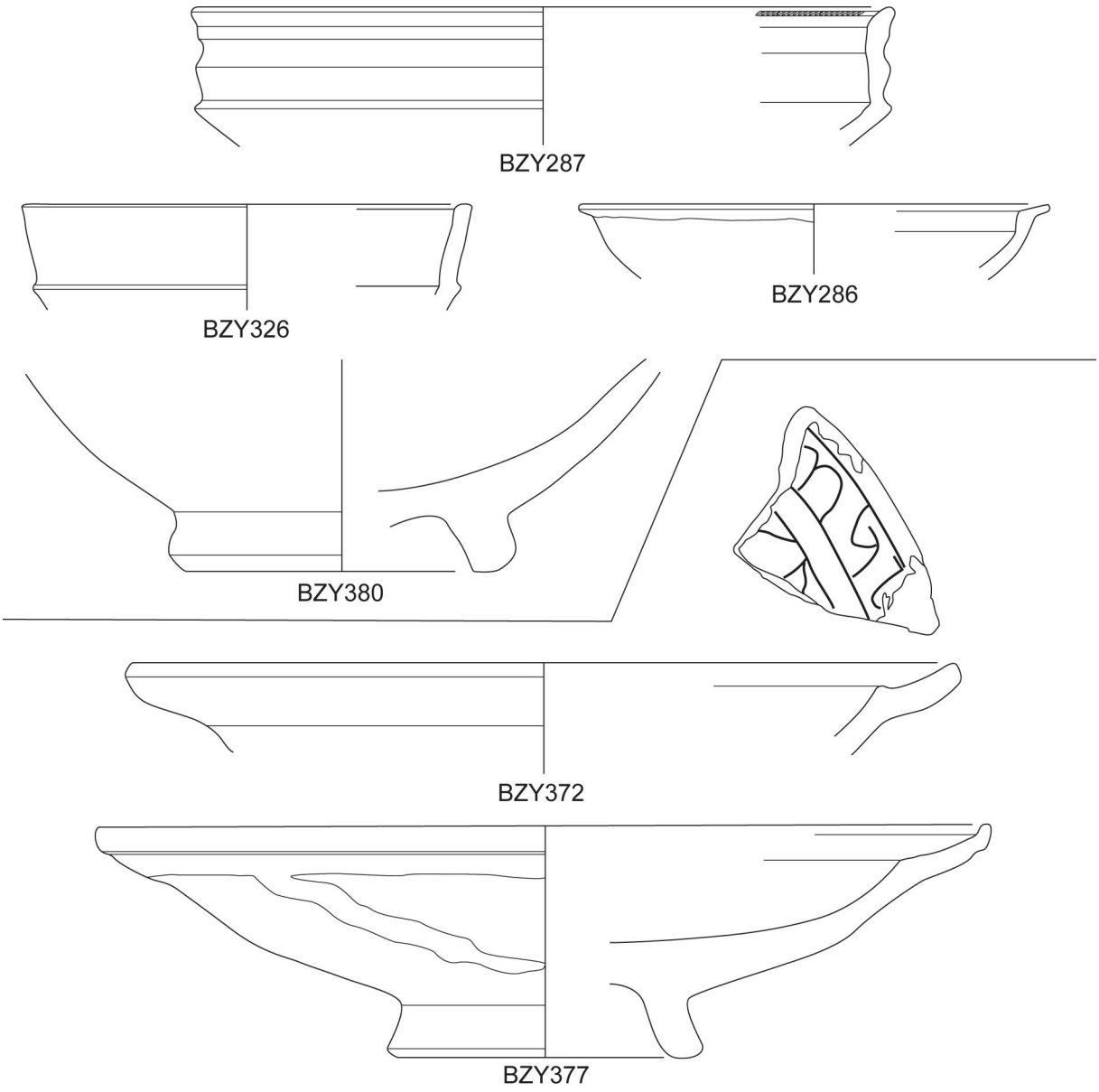

Figure 4: Examples of ceramics analyzed from Ephesos, belonging to local group c/4 (top) and b/2 (bottom) (scale 1/3, Ephesos team, N. Math, S.Y. Waksman).

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.[29]

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.

[29] Picon 1993, 3-25.

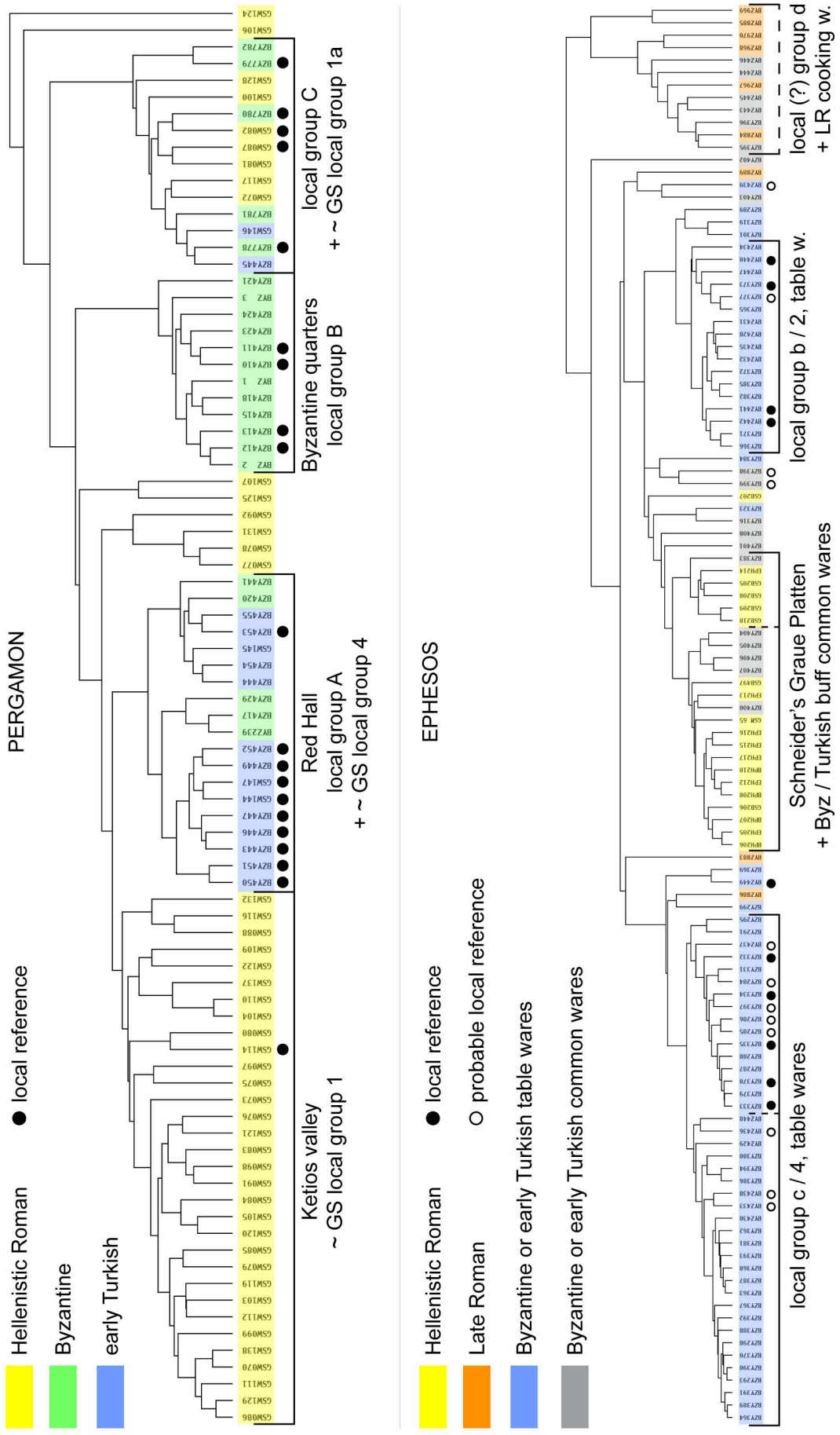

Figure 5: Classifications according to chemical compositions of ceramics from Pergamon (top) and from Ephesos (bottom), local productions of various periods and categories mainly.
Data from Lyon and Berlin laboratories, the latter include comparative data for samples from the Magdalensberg (cf. text).
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)[30] 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.[31] 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).[32]

Another group (local group A), corresponding to Schneider's group 4,[33] 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,[34] including two overfired sherds from the Ketios valley contexts (GSW082[35] [Perga 28], GSW087 [Perga 34]). It also includes the minor Byzantine group byzi[36] containing reference samples from the Byzantine quarters (BZY778-780).[37] 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[38]).[39] Post-depositional processes are probably responsible for the large standard deviations in strontium and baryum.[40]

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.[41] 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

[30] after Schneider & Japp 2009, 287-306.

[31] Waksman 1995; Waksman & Spieser 1997, 105-33.

[32] Megaw 1968, 67-88; Waksman & François 2004-2005, 629-724.

[33] Schneider & Japp 2009, 287-306.

[34] 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).

[35] 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.

[36] after Waksman 1995; Waksman & Spieser 1997, 105-33.

[37] Waksman 1995; Waksman & Spieser 1997, 105-33.

[38] after Waksman 1995; Waksman & Spieser 1997, 105-33, Schneider & Japp 2009, 287-306.

[39] Waksman 1995; Waksman & Spieser 1997, 105-33, Schneider & Japp 2009, 287-306.

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

[41] 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, σ: standard deviation, n: number of samples, ld: detection limits. Elements within brackets are indicative.

id.	CaO	Fe_2O_3	TiO_2	K_2O	SiO_2	Al_2O_3	MgO	MnO	(Na_2O)	(P_2O_5)	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
m	**4,60**	**7,11**	**0,936**	**3,49**	**59,69**	**18,86**	**3,23**	**0,1155**	**1,46**	**0,25**	**214**	**343**	**147**	**95**	**127**	**82**	**51**	**880**	**153**	**116**
σ	**1,01**	**0,44**	**0,057**	**0,27**	**1,27**	**0,86**	**0,26**	**0,0043**	**0,21**	**0,05**	**11**	**58**	**12**	**6**	**12**	**10**	**8**	**59**	**14**	**10**
local group 1 (n=37, Schneider and Japp 2009)																				
m	**5,39**	**7,16**	**1,001**	**3,37**	**60,56**	**18,60**	**2,90**	**0,110**	**0,60**	**0,213**	**182**	**317**	**144**	**94**	**257**	**156**	**36**	**685**	**153**	**83**
σ	**1,87**	**0,51**	**0,076**	**0,26**	**2,20**	**1,11**	**0,45**	**0,028**	**0,17**	**0,046**	**12**	**71**	**12**	**15**	**29**	**19**	**9**	**112**	**18**	**7**
Byzantine quarters, main local group																				
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_2O_3	TiO_2	K_2O	SiO_2	Al_2O_3	MgO	MnO	(Na_2O)	(P_2O_5)	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
m	**6,93**	**5,91**	**0,723**	**2,84**	**62,40**	**17,09**	**2,49**	**0,1174**	**1,48**	**0,22**	**193**	**340**	**134**	**86**	**96**	**65**	**48**	**1017**	**113**	**107**
σ	**1,10**	**0,18**	**0,025**	**0,11**	**1,00**	**0,40**	**0,18**	**0,0113**	**0,14**	**0,03**	**18**	**22**	**5**	**4**	**5**	**6**	**7**	**89**	**10**	**15**
main Byzantine local group (n=57, recalibrated data, Waksman and François 2004-2005 after Waksman 1995)																				
m	**7,04**	**5,79**	**0,757**	**2,90**	**61,10**	**17,18**		**0,1158**	**1,68**		**174**	**328**	**127**		**90**	**76**	**42**	**1021**		**84**
σ	**1,50**	**0,42**	**0,057**	**0,23**	**1,33**	**0,58**		**0,0085**	**0,17**		**49**	**30**	**11**		**10**	**17**	**2**	**123**		**4**
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
m	**2,84**	**8,55**	**1,122**	**4,24**	**56,17**	**21,42**	**4,00**	**0,1238**	**0,96**	**0,31**	**240**	**210**	**172**	**110**	**178**	**115**	**58**	**788**	**171**	**100**
σ	**0,59**	**0,40**	**0,042**	**0,22**	**1,94**	**0,77**	**0,44**	**0,0077**	**0,25**	**0,11**	**12**	**31**	**9**	**7**	**14**	**9**	**8**	**141**	**10**	**11**
local group 1a (n=10, Schneider and Japp 2009)																				
m	**2,71**	**7,94**	**1,091**	**4,24**	**57,96**	**21,56**	**3,25**	**0,118**	**0,89**	**0,221**	**217**	**204**	**165**	**109**	**221**	**133**	**39**	**817**	**191**	**95**
σ	**0,99**	**0,59**	**0,069**	**0,27**	**2,27**	**1,44**	**0,47**	**0,015**	**0,35**	**0,056**	**24**	**58**	**11**	**13**	**17**	**17**	**7**	**113**	**26**	**13**

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).[42] 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).[43] Group b/2 seems to correspond more specifically to new types introduced later on in the local repertoire, especially moulded[44] (BYZ440-442, BZY373, Fig. 3f)[45] and turquoise-glazed[46] wares (BYZ428, BZY365-366, 371, Fig. 3e).[47] 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.[48]

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)[49], 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;[50] 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 Ephesos at the Hellenistic / Roman and the late Byzantine / early Turkish periods. In both sites, reference

[42] The names of the groups refer to Sauer & Waksman 2005, 51-66, and Waksman forthcoming.

[43] Waksman forthcoming; Vroom & Fındık forthcoming.

[44] As far as we know there is no evidence for the use of moulds between the Roman and the Beylik periods.

[45] Vroom 2005, 34-5, type 6.

[46] 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).

[47] Vroom 2005, 30-2, type 2.

[48] Waksman forthcoming.

[49] Vroom 2005, 35-6, type 7; Sauer & Waksman 2005, 51-66, group d.

[50] 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_2O_3	TiO_2	K_2O	SiO_2	Al_2O_3	MgO	MnO	(Na_2O)	(P_2O_5)	Zr	Sr	Rb	Zn	Cr	Ni	(La)	Ba	V	(Ce)
local group c/4, late Byzantine and early Turkish table wares																				
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_2O_3	TiO_2	K_2O	SiO_2	Al_2O_3	MgO	MnO	(Na_2O)	(P_2O_5)	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
m	**1,50**	**11,19**	**1,020**	**4,24**	**52,72**	**23,59**	**3,68**	**0,1374**	**1,27**	**0,29**	**228**	**163**	**171**	**152**	**185**	**114**	**71**	**810**	**203**	**144**
σ	**0,33**	**0,47**	**0,019**	**0,18**	**0,85**	**0,57**	**0,35**	**0,0162**	**0,17**	**0,05**	**20**	**10**	**8**	**6**	**27**	**27**	**13**	**64**	**8**	**14**
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_2O_3	TiO_2	K_2O	SiO_2	Al_2O_3	MgO	MnO	(Na_2O)	(P_2O_5)	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
mixed group, including Schneider's "Graue Platten" attributed to Ephesos and Byzantine/early Turkish common wares																				
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	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	240	151	93	200	166	36	579	108	85

id.	CaO	Fe_2O_3	TiO_2	K_2O	SiO_2	Al_2O_3	MgO	MnO	(Na_2O)	(P_2O_5)	Zr	Sr	Rb	Zn	Cr	Ni	(La)	Ba	V	(Ce)
m	**11,66**	**7,23**	**0,710**	**3,51**	**53,41**	**18,80**	**3,40**	**0,1126**	**0,56**	**0,55**	**169**	**190**	**169**	**104**	**208**	**160**	**48**	**584**	**134**	**90**
σ	**1,84**	**0,46**	**0,017**	**0,26**	**1,86**	**0,78**	**0,67**	**0,0105**	**0,14**	**0,31**	**8**	**26**	**12**	**8**	**12**	**12**	**12**	**81**	**14**	**16**
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_2O_3	TiO_2	K_2O	SiO_2	Al_2O_3	MgO	MnO	(Na_2O)	(P_2O_5)	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
m	**3,90**	**8,42**	**0,973**	**3,99**	**55,82**	**21,05**	**3,85**	**0,0985**	**1,31**	**0,25**	**177**	**267**	**182**	**123**	**196**	**242**	**61**	**727**	**141**	**124**
σ	**0,89**	**0,21**	**0,037**	**0,20**	**1,07**	**0,79**	**0,33**	**0,0053**	**0,12**	**0,06**	**10**	**24**	**10**	**7**	**23**	**54**	**14**	**48**	**5**	**9**
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 processing,[51] 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.

[51] Clay processing concerns here ceramic bodies, and not surface treatments.

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