Archaeometric approaches to ceramics production and imports in Medieval Cyprus

S.Y. Waksman

To cite this version:
S.Y. Waksman. Archaeometric approaches to ceramics production and imports in Medieval Cyprus. Demetra Papanikola-Bakirtzi; Nicholas Coureas (eds.). Cypriot Medieval Ceramics: Reconsiderations and New Perspectives, The Cyprus Research Centre and The A. G. Leventis Foundation, pp.257-277, 2014. hal-02010350

HAL Id: hal-02010350
https://hal.univ-lyon2.fr/hal-02010350
Submitted on 6 Feb 2020

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Although pottery found on Cyprus has been the subject of many laboratory investigations using chemical analysis (e.g. Jones 1986 for a review until 1983, Rautman et al. 1993, Gomez et al. 2002, Picon and Blondé 2002, Hatcher 2007), very few were devoted to the medieval period. The pioneer work of Megaw and Jones (1983, Jones 1986) led the way, followed by Megaw, Armstrong and Hatcher (2003, Armstrong and Hatcher 1997) and only a few others, including the author (Waksman 2002, Waksman et al. 2003, 2005, Waksman and François 2004-2005, Waksman and von Wartburg 2006, von Wartburg et al. 2010, Charalamous et al. 2010, 2012). From the early to the post-Medieval periods, research carried out at the “Laboratoire de Céramologie” in Lyon concerned sites in different parts of Cyprus (including the northern part of the island), various categories of ceramics (common and cooking wares, table wares, industrial ceramics), and may refer to data included in the large Lyon database of chemical analyses (e.g. Cypriot late Roman amphorae LRA1, Empereur and Picon 1989) (Fig. 1). In this paper, we would like to both summarize some of the results of

![Map of Cyprus with pottery production sites](image-url)

Fig. 1: Pottery production sites on Cyprus presented (black dots) or mentioned (white dots) in the text
this research and present as yet unpublished data, concerning local production and imports on Cyprus.

The circulation of cooking wares in the early Byzantine period (Figs 2-3, Table 1)\(^1\)

Fig. 2/Colour Pl. XVIIIa: CATHMA 11 type and Dhiorios reference group. Top: example of CATHMA 11 type from Saint-Blaise (J.-C. Tréglia). Middle: samples analyzed from Dhiorios workshop; left (from left to right, top to bottom): BYZ 73, 74, 87, 78, 77, 88, 84, 83, 81, 82; right (from left to right, top to bottom): BYZ 79, 80, 89, 86, 75, 76, 92, 91 (photos Y. Montmessin). Bottom: samples analyzed from Dhiorios workshop (S. Elaigne, C. Brun, S.Y. Waksman). Chemical data are detailed in Waksman et al. 2003

1. BYZ, LIS, LEV., numbers refer to Lyon laboratory ids.
Fig. 3: Dhiorios reference group

Samples analyzed from Dhiorios workshop (S. Elaigne, C. Brun, S.Y. Waksman)
Chemical data are detailed in Waksman et al. 2003
Table 1: Chemical compositions of samples from Dhiorios and from Beirut workshops (groups and sub-groups of red and buff wares in the latter case)

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Table 1: Chemical compositions of samples from Dhiorios and from Beirut workshops (groups and sub-groups of red and buff wares in the latter case)

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 limit. Elements between brackets are indicative.
A first case study focused on types of cooking wares which met with a large diffusion in the whole Mediterranean in the late Roman / early Byzantine period, and were thought to originate from its Eastern part (CATHMA\textsuperscript{2} 1991, Waksman \textit{et al.} 2003, 2005). One of this type, characterized by a concave rim (CATHMA type 11, Fig. 2), had previously been attributed to the Cypriot workshop of Dhiorios (Catling 1972). The publication of the excavations at Dhiorios was of major interest, as an example of workshop specializing in cooking wares, and unfortunately still remains too isolated a case.

The production of Dhiorios had been characterized chemically at the Fitch Laboratory in Athens (Megaw and Jones 1983) and in Lyon (Figs 2-3, Waksman \textit{et al.} 2003). Chemical analyses of examples of CATHMA type 11 as well as of “Levantine” types (CATHMA types 4, 16, 29) found in various sites including Marseille and Beirut, showed that they all originated from the same production site (“Workshop X”), unlikely to be Dhiorios and probably located on the Levantine coast, possibly in the area of Tell Keisan (Waksman \textit{et al.} 2003, 2005, Reynolds and Waksman 2007).\textsuperscript{3} The result did not disagree with Catling’s publication, as CATHMA type 11 is in fact rare in Dhiorios itself, and may have been present there in a context of consumption and redistribution (warehouses) rather than in pottery dumps (Catling 1972, Waksman \textit{et al.} 2005). Further work showed that CATHMA type 11 was in fact produced in many more workshops, including Cypriot ones (Gabrieli pers. comm.,\textsuperscript{4} Reynolds and Waksman 2007),\textsuperscript{5} but the long distance exports were only attributed to “Workshop X” products so far. It is noticeable that the latter do not seem to include any other category of pottery (fine wares, amphorae).

These results suggested the existence of more workshops specializing, like Dhiorios, in cooking wares, a feature which may be related to the specific technical requirements implied by their function (especially resistance to thermal stress, e.g. Picon 1995, Tite \textit{et al.} 2001). Until recently, specialization occurred in traditional Cypriot workshops such as Kornos and Phini, famous for their common and cooking wares (Ionas 2000). Our study also pointed out the still under-estimated circulation of cooking wares in ancient times, as shown by our next case study as well.

2. The CATHMA association gathers ceramologists interested in the study of late Roman and early Medieval wares (cathma.ass.free.fr).


5. To which extent the diffusion of cooking wares models, which finds another good example at the same period in the so-called sliced-rim casseroles (Waksman \textit{et al.} 2005), also implied the diffusion of specific recipes and/or ways of cooking is under question; see also infra, POMEDOR project.
Fig. 4/Colour Pl. XVIIIb: Levantine imports on Cyprus
Top: samples analyzed from Saranda Kolones, Levantine imports from Beirut (S. Elaigne, C. Brun, S.Y. Waksman)
Bottom right: samples analyzed from Saranda Kolones, Levantine imports from Beirut (from left to right, top to bottom): LEV 93, 96, 98, 95, 94, 100 (photo Y. Montmessin, not to scale).
Chemical data are detailed in Waksman 2002
Bottom left: example of Beirut ware (LEV356) of “Islamic” type found in Tell Arqa (Lebanon), similar to ceramics found in Nicosia (von Wartburg and Violaris 2009) (photo S.Y. Waksman, not to scale)
Levantine imports in Cyprus at the Crusader period (Fig. 4, Table 1)

That cooking wares continued to circulate on a fairly large scale in subsequent periods was shown by the diffusion of Beirut products. Both table and cooking wares attributed to the Levantine area were found on Cyprus in significant quantities, especially in the region of Paphos (Megaw 1972, Megaw and Jones 1983, von Wartburg 1997, 1998, Gabrieli 2006, 2007, 2008, von Wartburg and Violaris 2009). Most of them, including sgraffito and reserved-slip table wares, cooking pots and baking dishes (Fig. 4), were shown to originate from the workshops of Beirut (Waksman 2002). Beirut products were very popular at the time in the whole Levantine area (Pringle 1986, Waksman 2002, Stern and Waksman 2003) and beyond (François et al. 2003, Waksman et al. 2009). Although quantitative data are still rare (Gabrieli 2006, Stern 1997, 2012, Stern and Waksman 2003), cooking wares appear as the dominant category in this diffusion. Other wares (especially slip-painted wares, Fig. 4: BYZ 97 to 100), sharing some common chemical features but seen as the output of distinct, not as yet located, workshop(s), are found associated in the same consumption contexts and probably followed the same trade networks (Waksman 2002, Waksman et al. 2008). Information provided by Cypriot sites (e.g. Megaw 1971, 1972, Gabrieli 2006, 2007, 2008, von Wartburg 1998, 2007, von Wartburg and Violaris 2009), together with other consumption contexts in the Levantine area (Stern 1997, 2012, Avissar and Stern 2005), are precious in understanding both these connections and the typo-chronologies of the different wares with greater precision.

“Crusader” Beirut also manufactured table wares of a different technological tradition, more specifically related to the “Islamic” world (Fig. 4, François et al. 2003, Waksman forthcoming a). Similar examples were found in Nicosia in twelfth century contexts (von Wartburg and Violaris 2009, von Wartburg et al. 2010), together with other possible Beirut products (cooking wares, sgraffito).6 Ceramics of “Islamic” type however seem to be rare on Cyprus (von Wartburg et al. 2010) when compared to “Levantine” types from Beirut, and especially to imports of Byzantine types.

The Byzantine table wares koine (Figs 5-9, Tables 2-3)

When looking more specifically at table wares, the dominant picture in both local production and imports is that of a territory belonging to the koine of Byzantine ceramics (e.g. Papanikola-Bakirtzis 2012). Further connections are seen with some areas of the Levant, especially the region around the gulf of Iskenderun (Alexandretta) and its productions related to the Port Saint Symeon

6. These attributions still need to be confirmed.
Fig. 5: Classification according to chemical compositions of samples (cf. Figs 6-9 and Table 2) from production contexts in Kato Paphos/Lemba, Lapithos, Potamia and from consumption contexts in the monastery of Saint Theodoros in Nicosia. Samples are identified by their laboratory number. Symbols indicate the site they come from, reference samples for local production (tripod stilts and pottery wasters) are pointed out (black symbols). The main compositional groups are underlined, the corresponding origin (Kato Paphos/Lemba, Lapithos and Potamia) or hypothesis of origin (Enkomi?) is indicated.
Ware (von Wartburg 2003, 2007, Redford 2004, this volume, Blackman and Redford 2005). The relationships between Cypriot, Byzantine and Levantine wares are complex, and the role of the Cypriot material in the study of the “Byzantine table wares koine” largo sensu has been fundamental.

Chemical analyses contributed to this study, by re-defining productions on the basis of the composition of the clay material used by the potters. They provided tools for research both on archaeologically attested workshops, and on wares manufactured in workshops not located so far. In the middle, late and post-Byzantine periods, workshops of glazed table wares, decorated with the sgraffito or slip-painting technique, are archaeologically known in or around Paphos, Lapi, Famagusta and Nicosia’ (Megaw and Jones 1983, Papanikola Bakirtzis 1989, 1993,

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<table>
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<th>Kouklia, sugar moulds and molasse jar</th>
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<td>BYZ291</td>
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<td>BYZ292</td>
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</table>

Table 2: Samples illustrated in other papers

7. Other workshops were mentioned, for instance in Solo and Limassol, but we do not know about the associated material (Papanikola-Bakirtz 1996, Violaris pers. comm.).
An example of chemical definition and differentiation of Cypriot productions is given by the classification shown in Fig. 5 (see Figs 6-9, Table 2 and annex for information on the samples considered, and on chemical analysis and classification techniques). Samples taken from production contexts in Kato Paphos - Lemba and Lapithos (Figs 6-7, Megaw and Jones 1983, Papanikola-Bakirtzis 1996, von Wartburg 1997, Waksman and

Fig. 6/Colour Pl. XVIIIc: Examples of samples analyzed from Kato Paphos/Lemba workshop.  
Top: tripod stilts (right) and sherds showing various fabrics and feet profiles (left)  
(photo S.Y. Waksman)  
Bottom: examples of profiles (S. Elaigne, C. Brun, S.Y. Waksman) and sample BYZ114 previously related to the “Zeuxippus Ware” *stricto sensu* and shown to belong to the production of Kato Paphos - Lemba (photo not to scale, after Waksman and François 2004-2005 and von Wartburg 1997)
Fig. 7/Colour Pl. XIXa: Samples analyzed from Lapithos workshop, including tripod stilts and unfinished (biscuit-fired) wares (from left to right, top to bottom): BYZ208, 205, 206, 207, 204, 203, 213, 212, 211, 210, 209 (photo Y. Montmessin)

Fig. 8/Colour Pl. XIXb: Samples analyzed from the monastery of Saint Theodoros in Nicosia, front (top) and reverse (bottom) sides (photos S.Y. Waksman)

Left (from left to right, top to bottom): BZY664, 665, 666, 672, 669, 667, 670, 668, 671

Right (from left to right, top to bottom): BZY676, 675, 679, 673, 680, 678, 674

Except for one (BZY670, closer chemically to the production of Potamia), all samples belong to a single chemical group. Their origin is as yet unknown; typological details relate them to ceramics tentatively attributed to Enkomi (Papanikola-Bakirtzis 1989)
Fig. 9: Samples analyzed from the monastery of Saint Theodoros in Nicosia
(C. Brun, J. Burlot, S.Y. Waksman)
François 2004-2005, Waksman and von Wartburg 2006) may easily be differentiated from a group of samples coming from consumption contexts in the Cistercian monastery of Saint Theodoros in Nicosia (Figs 8-9, Flourentzos 2004-2005).\(^8\) The latter are characterized by the frequent use of a red slip over a buff body (Fig. 8), similar to examples tentatively associated by Papanikola-Bakirtzis (1989) with workshops in Enkomi.\(^9\) They are closer chemically to common wares manufactured in Potamia\(^10\) (François and Vallauri 2001, Vallauri 2004, Table 2), a feature which would be explained by the location of both Enkomi and Potamia in the alluvial plain of the Gialias river (Devillers et al. 2006). The identification of this new chemical group to the production of Enkomi needs to be confirmed by further research. But the attribution to this production of different wares, such as the so-called “wedding bowls” for instance, may already be tested.

The identification of chemical reference groups previously gave us the opportunity to address various hypotheses concerning Cypriot workshops. Wares initially integrated by A.H.S. Megaw in his definition of the type “Zeuxippus Ware” (Megaw 1968) were separated by chemical analyses from the “Zeuxippus Ware \textit{stricto sensu}” and attributed to the area of Paphos (e.g. Fig. 6 BYZ114, Waksman and François 2004-2005). Conversely, the tentative attribution to Cyprus of several Byzantine types widespread in the twelfth and thirteenth centuries (Boas 1994, Blackman and Redford 2005), such as the “Zeuxippus Ware” and the main “Middle Byzantine Production”, including “Fine Sgraffito Ware”, “Aegean Ware” and others, was reconsidered and other hypotheses of origin tested or put forward (Waksman and François 2004-2005, Waksman and von Wartburg 2006, Waksman et al. forthcoming). In the case of the main “Middle Byzantine Production”, samples from Cypriot sites played an essential role in showing that different types, previously unrelated and treated as separate productions in reports and publications, originated in fact from the same workshop(s) (Waksman and von Wartburg 2006).

The diffusion of Cypriot wares is well attested in the Eastern Mediterranean and occasionally reached more distant areas such as the Western Mediterranean and the Black sea, as indicated for instance by examples found in Marseille and in the Novy Svet shipwreck (Vallauri and Démians d’Archimbaud 2003, Waksman et al. 2009). Next to the typical Cypriot types, wares found in large

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8. Ceramics from these contexts, excavated by E. Zachariou-Kaila, were recently presented, together with material from other excavations in Nicosia, in the exhibition “Fragments: Ceramic finds from Byzantine and Medieval Nicosia” (Department of Antiquities of Cyprus and Leventis Municipal Museum of Nicosia). Ceramic material from Saint Theodoros will be published by R.S. Gabrieli (in preparation).

9. This association was based on visual similarity with reference material from Enkomi.

10. A detailed presentation of the Potamia results is forthcoming.
quantities in Crusader Acre, initially related to Paphos wares and to the “Zeuxippus family”, were shown to differ chemically from them (Stern and Waksman 2003, Waksman et al. 2008) and attributed to the workshop of Anaia/Kadikalesi in Western Asia Minor (Waksman 2013).

Different ceramic products, different clay materials: examples from the Paphos area (Figs 6, 10-11, Tables 2-4)

Pottery manufacture took place in different locations in the area of Paphos. For the “late” periods, evidence of production was found for late Roman amphorae LRA1 in Kato Paphos (Fig. 10, Karagheorgis 1989, Demesticha and Michaelides 2001); for medieval glazed wares at the site of Fabrika in Paphos (Green and Cook 2002, Green et al. forthcoming, Cook this volume), in the nearby village of Lemba (Papanikola Bakirtzis 1993, 1996, von Wartburg 1997) and possibly in Palaipaphos/Kouklia (von Wartburg 1997); for sugar pots at the cane sugar refinery of the latter site (Maier 1978, von Wartburg 2010) and possibly in Lemba. For these three categories of pottery - table wares, amphorae, industrial ceramics -, different clayey materials were used, and probably at least to some extent chosen according to the function of the wares. For instance sugar moulds, for which porosity plays an important role in the sugar production.

Fig. 10: Samples analyzed from Paphos LRA1 amphorae workshop (Lyon database, Empereur and Picon prospectings)

Left: samples BAL236 (left), BAL231 (right) (photo S.Y. Waksman, courtesy M. Picon and J.-Y. Empereur).

Right: rim and handle profiles (C. Brun)
<table>
<thead>
<tr>
<th>Name</th>
<th>CaO</th>
<th>MgO</th>
<th>K2O</th>
<th>Na2O</th>
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<th>SiO2</th>
<th>TiO2</th>
<th>Fe2O3</th>
<th>Zr</th>
<th>Sr</th>
<th>La</th>
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<th>Ni</th>
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<td>1.70</td>
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</tr>
</tbody>
</table>

**Note:** The table above provides a representation of chemical compositions for samples labeled as Names 1 to 27. Each row represents a different sample name with its corresponding CaO, MgO, K2O, Na2O, Al2O3, SiO2, TiO2, Fe2O3, Zr, Sr, La, Cr, Ni, MnO, and FeO concentrations. The data is presented in a tabular format for ease of analysis and comparison.
Amphorae are made out of even more calcareous materials, and are further characterized by variable but usually high concentrations in strontium, which differentiate them from Cilician LRA1 (Waksman et al. 2014), and in chromium, probably due to minerals brought by streams from the nearby Troodos mountains (Table 4). In contrast, table wares do not have any ultra-basic features and are less calcareous, whether made in Kato Paphos - Lemba, in Nea Paphos - Fabrika or coming from Palaipaphos - Kouklia. The clayey material used for table wares is fairly variable (also in fabric, see Fig. 6 top left), especially in its contents of calcium and related elements, as may be seen within our sampling from Paphos/Lemba only (Fig. 5, Table 3). However, samples from the three sites are all included in the same range of compositions: they do not seem to

Table 3: Chemical compositions of samples from Kato Paphos - Lemba, Lapithos, Potamia and Nicosia, samples are ranked as in the classification (Fig. 5).

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 limit, nd: not determined. Elements between brackets are indicative.

Data for Paphos and Lapithos were previously published in Waksman and François (2004-2005) and Waksman and von Wartburg (2006)

11. Further archaeological research on Cypriot and Levantine sugar pots will be carried out in the framework of the POMEDOR project, see infra.
Table 4: Chemical compositions of samples from Paphos LRA1 workshop and of sugar pots and jars from Kouklia and Lemba.

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<th>K2O</th>
<th>SiO2</th>
<th>Al2O3</th>
<th>MgO</th>
<th>MnO</th>
<th>Na2O</th>
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<th>Rb</th>
<th>Zn</th>
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<th>V</th>
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<tr>
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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 limit, nd: not determined. Elements between brackets are indicative.
differ chemically in a significant way within this range (Fig. 11). We thus refer to them as “production of the Paphos region” or “Paphos Ware”.

To sum up, in different locations in or around the present city of Paphos similar clayey materials were used to manufacture table wares; on the other hand, materials showing very different chemical features were taken in Paphos to produce different categories of pottery. The latter point, well known for cooking wares, may have been under-estimated for other categories. This example of a rather complex situation reminds one that a single location may have several geochemical “signatures”. It calls for more caution when using chemical reference groups, especially when they do not directly correspond to the wares under study.

12. A detailed presentation of the Fabrika and Kouklia results is forthcoming.
Concluding remarks and further perspectives

Research carried out on ceramics found on Cyprus have been essential in building up our knowledge on medieval ceramics, whether table wares, cooking wares, amphorae or others. Even though many questions still remain open, it has contributed to establishing several results regarding pottery production and diffusion, trade networks, cross influences, some of which have been summarized here. Chemical analyses contributed to this study, by re-defining productions on the basis of the composition of the clay material used by the potters. They helped in distinguishing Cypriot products from imports, identifying typological repertoires and in ascertaining more precisely which types were associated within a same production. In addition, they provided information regarding organization of production, and diffusion of wares, models and techniques. Studies carried out on Cypriot samples contributed for instance in re-defining the main “Middle Byzantine production” and “Zeuxippus related wares”. Chemical reference groups for workshops in the region of Paphos, in Lapithos, Potamia, Dhiorios and elsewhere have been used and are available to test further hypotheses, as well as groups corresponding to workshops whose location still has to be identified or confirmed (e.g. “Enkomi?” group).

Much of our research has focused so far on proposing new criteria to consider medieval pottery in the Eastern Mediterranean, in terms of productions rather than in terms of types. The two approaches are complementary, but the former seems more adapted if one is to reason on production (associations of types, choice of materials, organization of workshops …) and diffusion (areas, fluxes, modalities of commercialization …). Further research may consider not only the circulation of goods, but also those of techniques and practices, especially those connected to food. Pottery as an approach to food and food-ways has still seldom been used in the medieval Eastern Mediterranean, with some noticeable exceptions (e.g. Papanikola Bakirtzis 2005, Gabrieli 2006, 2007, this volume, Vroom 2003, 2009). Food procurement as seen through products carried in transport amphorae, ways of preparing, cooking and consuming food as illustrated by common, cooking and table wares will be further explored in the framework of the POMEDOR project involving several contributors to this volume. Cypriot material will be of particular interest, especially through the detailed analysis of forms, functions and origins in their relationships to food and food-ways of Cypriot and imported cooking wares from closed contexts such as Odos Ikarou in Paphos (Raptou 2006, Gabrieli 2008). Another line of research addresses the introduction of new styles and technological features in locally produced medieval table wares, which may reflect on new tastes and


Acknowledgements

My research in Cyprus would not have been possible without the help of many archaeologists and ceramologists, to whom I would like to pay tribute to and to thank warmly for fruitful collaboration: the late A.H.S. Megaw and H. Catling, D. and Ch. Bakirtzis, M.-L. von Wartburg and F. Maier, S. Gabrieli, H. Cook, E. Zachariou-Kaila, E. Raptou, V. François, L. Vallauri. Many thanks are due to the Department of Antiquities of Cyprus, and to the staff of the “Laboratoire de Céramologie” in Lyon. This research was partly funded by the French National Research Agency (ANR) through the POMEDOR project, and we acknowledge the support of the ANR under reference ANR-12-CULT-0008.

Annex: chemical analysis and classification of samples according to chemical composition

Chemical analysis was carried out by Wavelength Dispersive - X Ray Fluorescence (WD-XRF) in the “Laboratoire de Céramologie” in Lyon. Samples are cut out with a diamond-coated saw, in a way which alters neither the profile nor the decoration of the sherd. Glaze and slip, when present, and an external layer, whose chemical composition is more liable to be altered during burial, are removed. After heating at 950°C (removal of water, volatiles, organics), cooling and grinding, 800 mg of ceramic powder is mixed with 3200 mg of flux (lithium metaborate and tetraborate). The mix is heated to liquid state in a gold and platinum crucible and is then cast into a bead. Analyses are carried out on these homogeneous beads, of fixed geometry, which correspond to a mean chemical composition representative of the initial material. Twenty-four elements are quantified, after calibration of the set-up using forty geological standards (CRPG, USGS, NIST, British Chemical Standards...). The calibration is frequently checked using three in-house pottery standards.

Seventeen elements are usually taken as active variables in multivariate statistical treatments used to classify ceramics into groups of similar chemical composition. These include major and minor elements in ceramics (MgO, Al₂O₃, SiO₂, K₂O, CaO, TiO₂, MnO, Fe₂O₃) and trace elements having various geo-

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chemical behaviour (V, Cr, Ni, Zn, Rb, Sr, Zr, Ba, Ce). Classifications enable us to constitute groups of samples having similar chemical compositions, which under certain conditions on the geological context may correspond to the production of the same workshop (Picon 1993). They are obtained in our case by hierarchical clustering analysis applied to standardized data, using euclidian distance and average linkage (e.g. Picon 1984). The corresponding diagram, called a dendrogram, initially represents each sample as a vertical bar at the base of the figure (Fig. 5). The two samples closest in composition are joined by a horizontal link, links closer to the base indicating closer similarity of the samples. They are then fused into a “pseudo sample” of average composition. Each pair of samples and “pseudo-samples” are then compared again, and fused by the same procedure. As samples become less similar, the level of linkage moves up the diagram until all the samples are connected. This constitutes the dendrogram, which shows clusters of samples which are similar connected towards the base, while clusters connected high up the dendrogram are less closely related. This representation is convenient, as it takes all the elements considered into account, but is not sufficient in itself to define compositional groups. Accurate interpretation still requires examination by the archaeological scientist of the individual data and of elemental differences between clusters.
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