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POMPEII AS A POTTERY PRODUCTION CENTRE
An archaeometric approach

Introduction

Recently a new project of archaeometric investigation focused on pottery production and circulation at Pompeii was undertaken in cooperation between University of Venice Ca' Foscari, the laboratory of ARCHEA[1] in Warsaw and the Free University of Berlin. The project[2] aimed to give a scientific description and interpretation to a number of wares of supposed local and regional production, retrieved during recent stratigraphic excavations undertaken in Regio VI, insulae 7 and 14[3] and by past excavations (1980–1981) carried out in the western part of the forum at Pompeii[4]. The issue of distinguishing wares locally manufactured at Pompeii from products manufactured in the surrounding region (so called Vesuvian region) was particularly crucial for the purposes of the above research work. The following contexts proved to be useful in order to define what could be securely identified as a local production:

1. The pottery from the filling of a pit (XB 11), part of a trench (XB) dug in the forum, next to the *basilica* area[5]. Among the retrieved ceramics, this layer yielded clear archaeological evidence for local pottery production, consisting of 78 complete kiln spacers, together with a large number of misfired pottery sherds in plain and black gloss ware and numerous sherds of red figured ware. The pottery can be dated by *comparanda* from the late 4th to early 3rd century B.C.
2. Further evidence for local (pottery wasters, moulds) and possibly local pottery production was detected in trench VII B and in probe VII, located alongside the eastern side of the sanctuary of Apollo[6]. A number of layers yielded, among other ceramics, abundant re-deposited votive material such as lamps, terracotta figurines, *thymiatheria*, miniature pottery and *unguentaria*[7]. The morphology and fabric of many of these objects suggested a possible local/micro-regional production of the votive material, likely to be connected with sanctuary needs.
3. A number of pottery wasters was retrieved during stratigraphic excavations carried out by the University of Perugia[8] in the *domus* VII,15,9–10 at Pompeii. The excavators identified a kiln active during the mid-2nd century B.C. The kiln was located north-west of the sanctuary of Apollo and archaeologists suggest that pottery production may have been functional to this sanctuary.

The typo-/chronological aspects of the examined ceramics are discussed in a separate contribution by Cottica et al. in this volume, while this present study aims to investigate local and regional productions from an analytical perspective.

Methodology

Three independent archaeometric methods of ceramic material classification were applied. Initially using MGR-analysis[9] the analysed sherds were grouped according to the plastic raw material used in their production. Then thin-section studies were used in order to describe the non-plastic part of the ceramic body as in the case of the natural clastic inclusions of the clay, or fine or coarse temper added by the potter. Finally, chemical analysis of all ten major elements and of a series of fifteen trace elements by wavelength-dispersive X-ray fluorescence (WD-XRF), together with multivariate grouping of the resulting data, allowed to establish which sherds were

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1 www.archaeometry.pl

2 Cfr. D. Cottica et al., Archeologia del paesaggio economico: le attività 2006-2007 tra scavo e laboratorio. In: S. Gelichi (ed.), Missioni Archeologiche e Progetti di Ricerca e Scavo dell'Università Ca' Foscari – Venezia. VI Giornata di Studio (Venezia 2008) 118–130.

3 For the ceramics and their contexts cfr. Cottica/Zaccaria Ruggiu forthcoming. Excavations were directed by A. Zaccaria Ruggiu, cfr.: A. Zaccaria Ruggiu, Lo scavo nell'insula VI,14,18–19. Riv. Stud. Pompeiani 14, 2003, 305–309; ead., Progetto Pompei: Regio VI insula 7. In: Ead. (ed.), Le Missioni archeologiche dell'Università Ca' Foscari di Venezia (Venezia 2004) 53–54; ead., Le ricerche dell'Università Ca' Foscari nell'insula VI,7. Riv. Stud. Pompeiani 16, 2006; ead., Progetti, ricerche, scavi archeologici dell'Archeologia Classica. Pompei. In: S. Gelichi (ed.), Le Missioni archeologiche dell'Università Ca' Foscari di Venezia (Venezia 2008) 89–111.

4 For the interim report cfr. P. Arthur, Problems in the urbanization of Pompeii: excavations 1980–1981. Antiqu. Journal 66/1, 1986, 29–44. For recent research on the excavation finds cfr. Cottica/Curti 2008.

5 For the location of this trench cfr. Cottica/Curti 2008 fig. 1a.

6 Cfr. Cottica/Curti 2008 fig. 1a and 2.

7 Cfr. ibid. 28–35. One of the most interesting layers is VII40, representing the filling of a pit filled in when rebuilding activities were carried out in the temple area in the II century B.C. cfr. Cottica/Curti 2008 fig. 9a–b.

8 Cfr. Anniboletti/Befani et al. 2007, 11–12. D. Cottica wishes to thank F. Coarelli and P. Braconi for allowing archaeometric analysis on some of the wasters retrieved in VII,15,9–10. The examined wasters were unfortunately shapeless and nothing can be said on their morphology contrary to Anniboletti/Befani et al. 2007, 12.

9 Daszkiewicz/Schneider 2001.

made from the same ceramic body, *e.g.* in the same workshop[10]. The limiting factor of grouping sherds using the above mentioned analytical methods is that the variation within a given workshop has to be known. Therefore many samples have to be analysed and the variation of all data received from the three methods have to be combined. This latter point is especially crucial in the study of the pottery from Pompeii and from the Vesuvian region. As it will be shown, MGR-analysis results in many groups slightly differing in composition. Not all these groups can be seen in the chemical data and, as an additional problem, chemical analysis and multivariate classification put together samples which are significantly different according to the thin-section studies.

Therefore the main problem to be solved was to establish reference groups in order to distinguish between workshops certainly active in Pompeii on the basis of archaeological evidence, other workshops present in the surrounding region and pottery from other provenances (*i.e.* non Vesuvian ceramics).

Altogether 121 samples from Pompeii were analysed from the context described above. A large number of analytical data on black and red gloss pottery from Campania were already available for comparison in the authors' database[11]. In addition, the Berlin data bank of some twenty-five thousand analyses comprises reference groups of *vernice nera* and *terra sigillata* from numerous sites in Italy and beyond[12].

The procedure of pottery analyses followed our down-up sampling strategy. Initially all 121 samples were classified by refiring small fragments at 1100° and 1200° C (abridged MGR-analysis). As identical refiring behaviour corresponds to a similar chemical composition[13] (if the influence of the coarse inclusions could be neglected), 23 samples had not necessarily been analysed by WD-XRF, so we could reduce costs. Based on the resulting compositional groups, 52 thin-sections have been studied, a number which certainly should be increased in the future. These latter studies turned out to be essential in distinguishing *e.g.* the local reference group and sigillata Puteolana which overlap in chemical composition, so that for some samples a secure attribution can not be made without the study of a thin-section, or without significant archaeological arguments which, on the other hand, have to be proved by analyses.

Local pottery production at Pompeii

Group 1a

One result of the study is very clear. The analysed distance holders, four of the five green wasters, fourteen of the sixteen black gloss wasters found in the stratigraphic unit XB 11, form one homogeneous group coded as group 1a. This group includes also the nine analysed sherds of red figured ware from the same context. This compositional group therefore certainly represents a reference group of locally produced fine wares in Pompeii. From chemical analysis, MGR-analysis and thin-sections fifteen samples from other find places supposed to be of local origin could also be attributed to group 1a. These samples include six black gloss sherds, two of which display a grey core like Campana C. The analysed items belonging to this group contain one of the miniature vessels from the temple of Apollo, a mould and four lamps of type Esquilino and type Ricci C, one of them regarded as a waster. One sherd of terra sigillata with a coarse fabric and one lead-glazed sherd are also matching group 1a, showing that the same raw materials were used over a long period of time and for very different pottery types[14]. The mean, standard deviation and coefficient of variation of the chemical analyses of group 1a samples are given in **table 1**[15].

Vessels belonging to group 1a are made from calcareous clay with Calcium contents between 10 and 16 % CaO. The clay contains microfossils e.g. *foraminifera* (**fig. 1a–c**) and quartz and, depending on the firing temperatures, fine mica. Larger inclusions are of volcanic material of up to 1 mm grain size, consisting of rock fragments (**fig. 1d**), pyroxene and feldspar (**fig. 1a.c**). Fragments refired at 1200° are molten to a round ball with pale to dark olive green colours which also could be brown-olive green, or olive green, with brown irregular distributed parts indicating some mixing of clays. By refiring behaviour and thin-sections, a few subgroups could be distinguished: these however need more analytical research before an assured interpretation can be brought forward.

Group 2

A further group of samples in refiring and in chemical analysis turned out to be similar to reference group 1a but with distinct higher contents of Sodium. These samples form the compositional group 2 which is much more inhomogeneous than group 1a, with clearly visible subgroups. One of these subgroups combines three wasters from a kiln excavated in *domus* VII, 15, 9–10 by the University of Perugia. The mean composition of these wasters is shown in **table 1** and compared to the overall mean of group 2. Group 2 comprises samples of moulds, bricks, lamps, common ware, miniature ware and, like in group 1, terra sigillata. In all six thin sections which have been made of group 2 samples, the presence of typical inclusions of volcanic material (**fig.**

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[10] A detailed description of the methods is given in the paper by Daszkiewicz et al. in this volume.

[11] Most of these data were the result of past studies already presented elsewhere (Soricelli et al. 1994; Faber 2003).

[12] e.g. Hedinger 1999a, b; Schneider 2000, 2009; Schneider/Daszkiewicz 2006.

[13] This is based on experience of several thousand samples analysed both by MGR-analysis and WD-XRF.

[14] Within this context it is interesting to note that the mean of three chemical analysis of sigillata from Pompeii made by ICP-MS (cfr. J. McKenzie in: Cottica/Zaccaria Ruggiu forthcoming) is similar to our reference group 1a. She called this mean CRSW2 (Campanian Red Slip ware). Her second group CRSW1 of three samples of sigillata found at Pompeii chemically corresponds to Production A sigillata (see footnote 21).

[15] Because some samples were attributed to group 1a only by MGR-analysis, the average is made of the 27 samples which have been analysed also by WD-XRF.

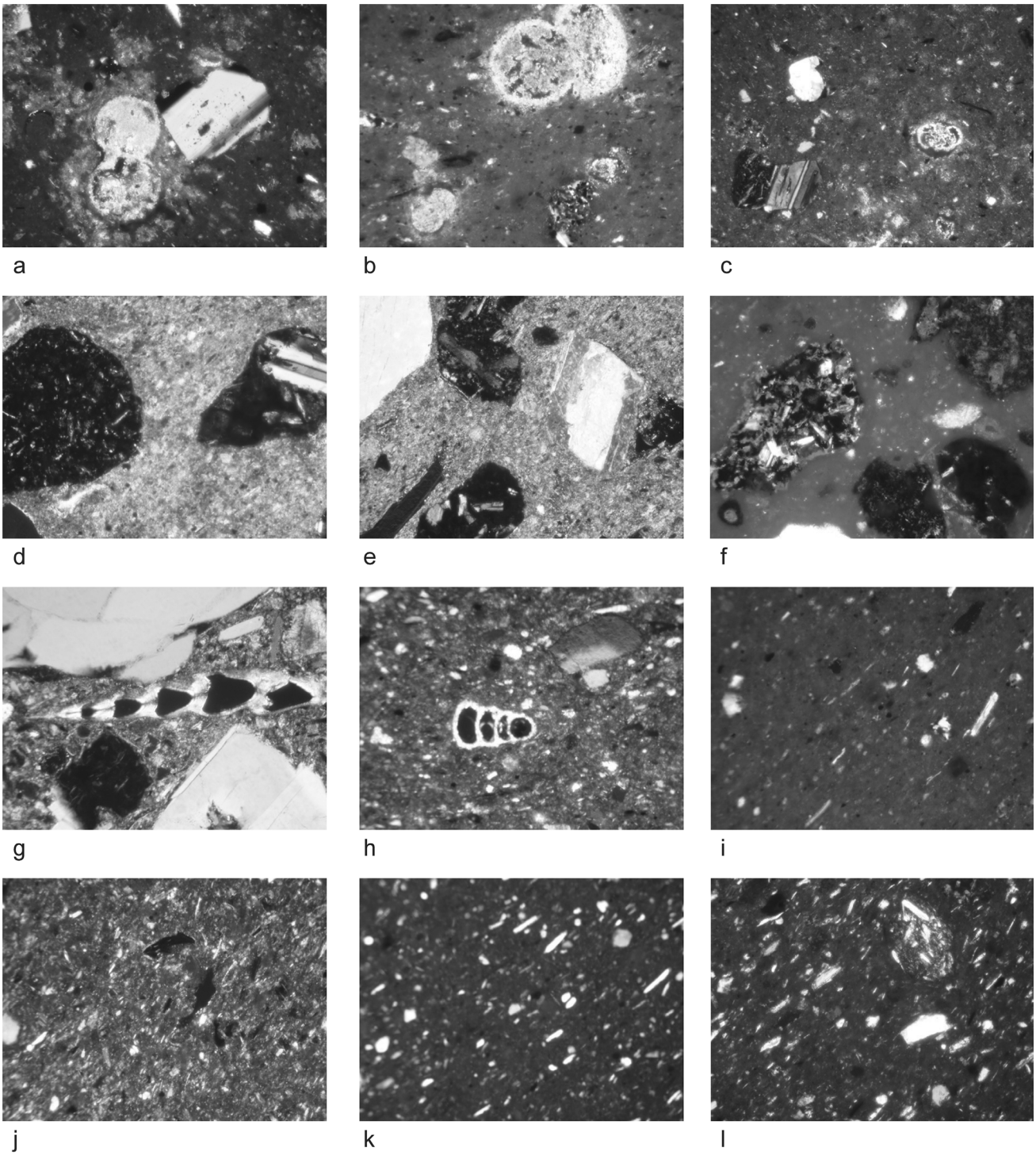

Fig. 1. Photomicrographs of typical micro-fabrics and inclusions (XPL, width of field 0.7 mm): **a)** lamp of type Esquilino (V729/group 1a) showing microfossil and plagioclase; **b)** mould (V732/group 1a) with two microfossils and a volcanic rock fragment; **c)** miniature vessel (V872/group 1a), inclusions as in fig. 1a; **d)** terra sigillata (V738/group 1a), coarser volcanic inclusions in a lower fired matrix than in figs. 1a–c; **e)** mould (V733/group 2a), inclusions and matrix as in fig. 1d; **f)** common ware (V748/group 2b), volcanic inclusions in a high fired isotropic matrix; **g)** brick (V755/group 3), showing microfossil, plagioclase and pyroxene; **h)** sigillata Puteolana (5369), high fired red matrix with fine mica, **i)** regional imitation of Eastern sigillata (V975) with inclusion of a microfossil and pyroxene in calcareous matrix with fine quartz and mica; **j)** Production A sigillata (V776), black spots are tiny glass fragments, **k)** sigillata from Arezzo (4898), high fired red matrix with fine mica**; l)** Gnathia style pottery (MD4210), inclusion of a micaceous rock fragment in red matrix with quartz and fine mica.

1e–f) and rare microfossils confirms the similarity to group 1a. The mean of Dressel 1 amphorae of Eumachi analysed by Thierrin-Michael and Maza[16] and believed to represent the local products at Pompeii corresponds well to the mean of group 2. In spite of its large variation, group 2 may be taken as a second reference group for local pottery manufactured at Pompeii.

Miscellaneous local or regional wares

Three bricks of supposed local fabric have also been analysed. They form a homogeneous group in MGR-analysis. Thin-sections display the same inclusions as in group 1a but in larger sizes e.g. volcanic rock fragments and microfossils (**fig. 1g**). The bricks chemically differ significantly from local groups 1a and 2 (**table 1**) and certainly were made from other raw material available within the Vesuvian area. The same can be said of Pompeian Red Slip ware, of which two groups could be distinguished.

On the basis of macroscopic observation, archaeologists identified two further groups of fabrics of possible local origin. All samples belonging to these latter two macroscopic fabric groups after analysis turned out to belong to various compositional groups, which all differ significantly from reference groups 1a and 2. Part of these samples[17] is characterized by Calcium contents below 8 % CaO and very high values of Lanthanum, Cerium, Yttrium and Niobium. Refired fragments are slightly overmelted with a brown colour. This behaviour and composition differs from that of reference group 1a. Volcanic inclusions in thin-sections, however, show that this pottery was also made within the Vesuvian area.

All the other analysed black gloss pottery, lamps[18], moulds, *unguentaria*, miniature vessels (all from trench VII by the sanctuary of Apollo) and common ware belong to various clearly distinguishable groups, most of which by thin-sections are characterized by volcanic inclusions and thus, as long as proofs for a local production at Pompeii are lacking, must also be regarded as regional products[19].

Some remarks on terra sigillata and "Gnathia style" pottery

Most of the analysed samples of terra sigillata are imports to Pompeii which can be attributed to known production centres. Puteolana sigillata is chemically very similar to the local pottery of group 1a but, in spite of similar high Calcium contents it is very different in thin-sections (**fig. 1h**), which do not display any volcanic inclusions of rock fragments or pyroxene. As an example of typical Puteolana ware, the chemical composition of a sherd stamped SERENI Q. POMPEI[20] is given in **table 1**. A group of three analysed samples of sigillata imitating Eastern sigillata forms, but with volcanic inclusions and *foraminifera* in thin-sections (**fig. 1i**), could be distinguished. Chemically the group is very similar to group 1a and to Puteolana. It certainly represents local or regional products. Other sigillata sherds stamped ICVII (?) and PHILEROS (in Greek letters) belong to the well known group of Production A Sigillata[21], characterized in thin sections by tiny glass fragments (**fig. 1j**); only in rare cases volcanic inclusions of larger size can be seen. Similar, but larger, glass fragments of a more brownish colour are typical for Campana A to which an analysed *thymiatherion* could be attributed. Chemically the two groups of red and black gloss pottery from workshops in Naples[22] are characterized by high Sodium and Potassium contents and very low Chromium and Nickel traces (**table 1**).

Several sherds could be attributed to sigillata Aretina as for example a sherd stamped C.VIBIEN/FAVST. Although in thin section sigillata from Arezzo (**fig. 1k**) is very similar to Puteolana (**fig. 1h**), chemically it can be distinguished by somewhat higher contents of Titanium, Chromium and Nickel.

A last group of likely imports is represented by a few analysed sherds of "Gnathia style" pottery. Their chemical composition does not match published data for Gnathia style pottery from Taranto[23] and thus the group represents another workshop of this pottery (**table 1**). In the thin-sections volcanic inclusions are lacking (**fig. 1l**), as any other indication of the production area.

Conclusions

Laboratory research clearly demonstrates that local pottery of group 1a, Puteolana and Cales are chemically quite similar and a secure attribution of individual sherds needs additional analysis of thin-sections or MGR-analysis. In spite of a large number of chemical data available for pottery from Campania, MGR-analysis should be made on a larger scale to get independent arguments for a precise distinction between the various compositional groups[24].

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16 THIERRIN-MICHAEL/MAZA 2002.

17 These are a little black gloss cup and a mould (group 6), *thymiateria* and a terracotta figurine (group 7).

18 There are at least two groups of lamps of type Ricci C. In group 1a are three such lamps together with a lamp of type Esquilino, the remaining seven lamps of type Ricci C, with inclusions of volcanic rock fragments and slate, form group 8 with subgroups 8a-c.

19 Analytical data of these items and a more detailed interpretation will be published in a separate paper.

20 A full discussion of the analysed stamped terra sigillata is presented by E. TOMASELLA in: COTTICA/ZACCARIA RUGGIU forthcoming.

21 This name used by PEÑA/MCCALLUM 2009, 113, instead Soricelli's "produzione A di Baia di Napoli" (also known as "Tripolitanian Sigillata") is given preference to the name Campanian Red Slip Ware (CRSW) used by McKenzie (see footnote 14) which is not unequivocally connected with this group of sigillata and also could be mixed with Cypriot Red Slip Ware.

22 Finds from a workshop for Campana A had been analysed (SORICELLI ET AL. 1994), including one clay sample found within this workshop. This sample, however, did not derive from a geological layer and could also have been imported from the island of Ischia as was hypothesized (e.g. by PICON 1994). The clay used for Produzione A differs significantly from the clay used for Campana A.

23 PRAG ET AL. 1974; HATCHER ET AL. 1980.

24 Comparison of refired samples of various sigillata (MGR-analyses) was presented at a conference in Rome (M. DASZKIEWICZ/E. BOBRYK/G. SCHNEIDER, Provenance of Terra Sigillata determined by MGR-Analysis. Poster at the RCRF Congress in Rome 2002).

		SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	V	Cr	Ni	(Cu)	Zn	Rb	Sr	Y	Zr	(Nb)	Ba	(La	Ce	Pb	Th)
		% by weight										ppm														
reference group 1a:	mean	54.52	0.779	17.54	6.59	0.088	3.15	12.97	0.85	3.12	0.43	154	150	66	49	104	147	446	27	153	19	351	31	75	24	14
(n = 27)	std ±	1.25	0.023	0.61	0.20	0.007	0.21	1.21	0.21	0.35	0.13	16	6	3	9	12	18	38	2	7	2	48	10	8	17	6
	cv %	2.3	2.9	3.5	3.1	7.5	6.6	9.4	24.7	11.2	31.2	10.7	4.2	4.6	19.1	11.3	12.1	8.5	7.2	4.7	11.9	13.8	32.0	10.6	69.3	44.0
kiln wasters (n=3)	mean	58.17	0.676	15.46	5.88	0.101	3.30	10.39	1.83	3.73	0.46	168	134	42	15	68	173	417	25	203	23	755	32	89	22	15
reference group 2:	mean	56.01	0.804	17.41	6.87	0.121	3.47	9.76	1.52	3.40	0.39	174	139	52	35	94	170	432	30	218	30	720	49	108	53	21
(n = 11)	std ±	2.03	0.085	1.56	0.76	0.019	0.58	1.91	0.24	0.32	0.07	20	16	8	19	19	22	46	4	20	5	57	17	17	30	4
	cv %	3.6	10.5	9.0	11.1	15.9	16.7	19.6	15.9	9.5	19.0	11.5	11.8	15.5	54.5	20.2	13.0	10.7	13.6	9.3	16.9	8.0	34.1	15.7	56.9	20.9
bricks (2008/2-3)	V755/756	59.95	0.648	16.50	4.95	0.115	1.69	8.18	2.68	4.94	0.35	99	71	31	33	83	155	324	29	205	26	424	37	88	32	18
Puteolana (2111)	V772	53.00	0.753	17.15	6.36	0.094	3.30	15.52	0.67	2.91	0.23	124	139	59	34	106	130	427	26	146	18	302	36	83	23	13
imitation ESA,C,D (2850)	V773	53.64	0.745	17.33	5.97	0.093	2.67	15.12	0.68	3.24	0.52	134	122	52	57	114	153	494	26	176	19	392	39	78	52	10
Production A (2108)	V765	58.58	0.725	18.27	6.15	0.140	1.98	7.33	1.79	4.69	0.35	85	64	37		133	217	359		281		714				
Campana A (336)	V977	61.61	0.727	20.12	5.19	0.109	1.35	2.85	3.08	4.75	0.22	92	35	21	27	118	271	188	34	373	50	369	78	162	52	37
Arretina (2110)	V763	55.42	0.909	19.47	7.87	0.162	3.72	8.85	0.67	2.67	0.26	148	175	96	60	140	143	286	35	132	23	417	49	101	26	
Gnathia (4297)	MD4210	59.23	0.860	19.97	6.39	0.110	2.41	5.98	1.00	3.68	0.37	133	129	48	49	123	195	273	37	219	23	579	49	107	31	15

Tab. 1. Chemical analyses by WD-XRF of local pottery groups 1a and 2 from Pompei compared to the mean of three kiln wasters from domus VII.15.9–10, and to the mean of two bricks with local fabrics, and to several black or red gloss wares given here as examples (inv. nos. given in brackets).

As far as fine wares in group 1a are concerned, the question of the origin of the clay used by potters in Pompeii is still not solved, although archaeological evidence[25] clearly attests that these were locally manufactured at Pompeii. The calcareous clay containing *foraminifera*, quartz and mica, in spite of some volcanic inclusions, is not of volcanic origin and very probably was not available in the immediate surrounding of Pompeii. Its composition is typical for calcareous marine clay and it was used in the production of the black (and red) gloss pottery. On the other hand, not all of the volcanic inclusions can be explained as local volcanic sand added by the potter and in the finer fabrics of group 1a the inclusions look more like original contents of the clay. Therefore, the provenance of the clay should be located in an area touched by the ashes of the Vesuvius but different from the volcanic glass containing ashes present in the clays used by potters in Naples.

The problems of the provenance of the clay used in Pompeii were discussed in much detail by Peña and McCallum[26]. Analyses by neutron activation of ten fired clay samples are given in their paper including seven samples of Miocene marine clay from Ogliara and Montecorvino in the Salerno region. However, only four of the nine important major elements are determined and the series of trace elements differs from the trace elements determined for the purposes of this present paper by WD-XRF. Therefore the comparison of the Peña/McCallum data with the data presented here has only a limited value. The contents of the twelve comparable elements, however, are very similar to those of groups 1a and 2. Certainly, further studies will be useful: these should include a larger series of clay samples fired at various temperatures up to 1200°C, to be compared with the results of MGR-analyses and thin-section studies of the fired clay samples. This methodology will be necessary to confirm the hypothesis that clay from the Salerno region was used for producing fine wares in Pompeii.

Finally, it is of interest to note that combined archaeological and archaeometric evidence suggests the presence of pottery kilns operating between the late 4th and the mid-2nd century B.C. in the forum area, probably connected with the sanctuary of Apollo. From the mid-2nd century B.C. onwards, following the significant rebuilding activities and changes that affected the urban layout of Pompeii, pottery workshops disappeared from the forum area. The model sanctuary/pottery workshops was dismissed and kilns moved to new locations, functionally fitting to the network of streets and city gates, and focused on an efficient connection between the city and its hinterland[27].

[25] Especially the large amount of wasters and potter's tools (kiln spacers).

[26] Peña/McCallum 2009.

[27] Cfr. the paper by McCallum/Peña in this volume.

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