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SCIENTIFIC INVESTIGATIONS ON THE PROVENANCE OF THE BLACK GLAZED POTTERY FROM POMPEII: A CASE STUDY

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ABSTRACT

Optical microscopy (OM), X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) spectrometry have been applied to the analysis of Black Glazed pottery from Pompeii (Italy), to have information about their provenance. The ceramic sherds, dating from the fourth century BC to the first century BC, were considered, on the basis of archaeological assumptions, to be locally produced.

Clayey sediments from the Salerno area were sampled as a potential source for the production of these ceramics and therefore investigated with the same analytical techniques. The comparison of sampled clays and pottery sherds provided evidence for their compositional similarity, in particular by use of a multivariate statistical approach (PCA). The compatibility of the raw materials considered is clearly in evidence and corroborates the use of these possible sediments for the production of the ceramic body of the Black Glazed pottery.

KEYWORDS: Pompeii, Black Glazed pottery, archaeometry, provenance

1. INTRODUCTION

This article describes a provenance study carried out on Black Glazed pottery found at Pompeii. The pottery dates from the fourth and third centuries BC to the first century BC and is considered to be a local production. The article forms the second part of earlier work by Scarpelli *et al.* (2014) in which technological aspects of the ceramics were evaluated. The provenance (Pompeii area) was indicated by archaeological assumptions (Arthur, 1986) in consideration of the great quantity of ceramics, kiln spacers and misfired pottery found during the I.E. (= Impianto Elettrico) excavations in 1980-81; these corroborate the hypothesis of an active production during the fourth and third centuries BC. Despite the lack of an identified kiln, recent archaeological studies suggested the operation of fine ware pottery workshops integrated within the urban network until the middle of the 2nd century BC (Cottica *et al.*, 2010, 2016; Schneider *et al.*, 2010). Subsequently ceramic production was organized in peripheral manufacturing districts, well connected with the hinterland, as made evident by a common ware kiln close to the Porta di Stabia (De Bonis *et al.*, 2013).

The mineralogical, petrographic and chemical analyses on Black Glaze potteries suggested the consistent use of fine calcareous clays over a long timespan and probably from the same catchment area. The groups analysed, related to two different periods of production, evidenced small variations, due probably to the technological changes in the preparation of the raw materials (levigation, settling and sieving), or to the different sedimentation conditions and/or alteration history of the source rocks in the clay deposits (Scarpelli *et al.*, 2014)

Considering the possible raw materials suitable for the ceramic production, clayey outcrops of different age and origin are widely exposed within the Campania region. De Bonis *et al.* (2013) investigated different clayey sediments by petrophysical analyses. The raw material sources were grouped into high-CaO clays (HCC) and low-CaO clays (LCC). HCC are mainly represented by Miocene-Pleistocene clayey foredeep sediments whereas LCC tend to be associated with foredeep alluvial, and pyroclastic deposits.

Peña and McCallum (2009) review the evidence for the availability and use of raw materials for the production of pottery at Pompeii and indications of the distribution of ceramics to and within the town. They considered the exploitation of marine clays, typically fine grained, calcareous and highly plastic, suitable for the manufacture of fine, wheel-thrown forms and mould-formed vessels. They identify in the Salerno province, the nearest sources of marine clay to the town of Pompeii considering their intense use for the manufacture of both architectural ceramics and pottery in the modern period.

The chemical comparison between clayey raw materials and Campanian archaeological ceramics of several typologies (common ware, cooking ware, fine tableware, amphorae and bricks) in De Bonis *et al.* (2013), indicates that HCC were extensively used for common wares and that these were either mixed with temper or levigated. However these materials, were employed generally for the production of fine ceramics in view of their optimal moulding and sintering properties(Šegvić *et al.*, 2012).

Considering the paucity of provenance studies and analyses of ceramics from Pompeii town, the present work aims to increase the body of data available on one of the most important archaeological sites of the world. The results could be used for future comparison with Black Glazed pottery of probable extra-regional origin. However, to corroborate the archaeological assumption about local provenance of Black Glazed pottery and to follow the suggestions of Peña and McCallum (2009), in the present work Salerno clays were collected and investigated in order to evaluate the similarity with ceramic sherds. Two important outcrops of Miocene-Pleistocene clayey sediments, close to Ogliara and Montecorvino towns, were also extensively sampled to evaluate possible compositional variations in these very thick marine deposits.

Ceramics and clays were analysed by Optical microscopy (OM), X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF), methodologies widely used in archaeometry. In particular XRF is very suitable for provenance studies of fine ceramics; the chemical characterization allowed comparison of clays and ceramics by multivariate statistical processing and to verify the archaeological hypothesis.

2. THE BLACK GLAZED CERAMICS

The pottery sherds, selected for comparison with sampled sediments, were previously analysed by Scarpelli *et al.* (2014) and are representative of two large homogeneous groups of Black Glazed pottery recognized during archeological excavations in the area of the Forum at Pompeii in 1980-1981. Group 1 represents the early production, dating to the fourth - third centuries BC (i.e. Morel F 62220, F 4342, 4372, 4373, F 2433–2434); Group 2, dating to the second–first centuries BC (i.e. Morel F 2257–2258, F 2323, F 2942), represents the later production (Fig.1).

These samples are mainly fragments of plates and bowls and are considered to be produced in Pompeii (Cottica *et al.*, 2017). In the present work, five new ceramic sherds of Group 2 (tab. I), were added to confirm the homogeneity of the chemical composition of this ceramic class from Pompeii. A detailed description of the sherds (correlated to photographs, drawings and inventory numbers) is given by Cottica *et al.* (2017).

Figure 1. Representative images of Black Glazed ceramics from Pompeii.

Table I. Summary of the Black Glazed pottery samples from Pompeii, analysed in Scarpelli et al. (2014) and in this paper.

sample	*Inventory number*	*typology*	*age*
Scarpelli et al., 2014			
VN1	5642	bowl	III BC
VN2	6716	*skyphos*	IV cent. BC
VN3	5620/1	bowl	IV-III cent. BC
VN4	7589	plate	III BC
VN5	5578	bowl	III BC
VN6	6604	*skyphos*	IV cent. BC
VN7	5780	bowl	IV-III cent. BC
VN8	8789	*skyphos*	III BC
VN9	5640	bowl	IV-III cent. BC
VN10	5559/1	bowl	IV-III cent. BC
VL1	3831	plate	II cent. BC
VL5	3608	bowl	I cent. BC
VL6	3385	bowl	II cent. BC
VL7	3654	unknown	II cent. BC
VL10	3671	bowl	I cent. BC
This paper			
VL8	10797	plate	II cent. BC
VL9	6390	bowl	II cent.BC
VL11	6218	bowl	I cent.BC.
VL13	9164	unknown	unknown
VL14	7797	*patera*	I cent. BC

3. RAW MATERIALS

Figure 2 shows a simplified sketch map of the geology of the area around Pompeii, where the distribution of clay deposits is widespread throughout the Campania region.

Campanian clayey deposits are mainly associated with siliciclastic and/or carbonate marine basinal sedimentary formations. The older sediments (e.g. Liguride, Sicilide units) belong to the preorogenic basinal domains of the Lower Cretaceous to the Upper Miocene (Bonardi *et al.*, 2009; Vitale *et al.*, 2011). Clayey deposits are also found in more recent (Miocene-Pliocene) successions deposited in synorogenic foredeep (e.g. Pietraroja formation) and *wedge-top* basin domains (Bonardi *et al.*, 2009; Vitale and Ciarcia, 2013). Clay sediments belonging to the quoted domains, crop out near Salerno and represent in particular the basal part of the Salerno-Montecorvino Rovella Unit (Pappone *et al.*, 2010). These consist chiefly of grey-blue clay and silty clay cropping out extensively between the calcareous Picentini Mts. and the Sele River alluvial plain (Geological map n.467 Salerno - *Istituto Superiore per la Protezione e la Ricerca Ambientale* – at 1:50.000 scale - 2009).

The sampling area was chosen according to its proximity to both the possible ancient site of production and the main Roman roads of the Campania region (Fig. 2) and also on the basis of suggestions by Peña and McCallum (2009) which identified in the Salerno province, the nearest sources of clay to the town of Pompeii, for the possible production of fine ceramics. Two outcrops were selected 8 km (Ogliara) and 28 km (Montecorvino Rovella) away from Salerno.

Five samples respectively, were collected from Ogliara (acronym OGL) and Montecorvino Rovella (acronym MCV and MC2) sites. The clays were sampled at fairly regular intervals from deposits. The clay sediments of Ogliara were collected by the outcrops of Rufoli, close to the A3 highway (40°41'47.3"N 14°48'52.9"E; 160 m – 200 m a.s.l.**).**

The clays of Montecorvino Rovella were collected from the top of the outcrops (MCV sample - 40°41'05.9"N 14°58'26.4"E; 280 m a.s.l.) and close to a dismissed furnace for the production of bricks (MC2 samples - 40°41'03.1"N 14°58'38.8"E; 240 m a.s.l).

4. ANALYTICAL METHODS

Investigations on Pompeii ceramics and clayey materials were performed at the University of Calabria, Department of Biology, Ecology and Earth Sciences, Cosenza, Italy.

Petrographic analysis of thin sections (OM - Optical Microscopy) was carried out on all ceramic sherds under a Zeiss polarized light microscope to describe the fabric, matrix and type of temper of the ceramic sherds following the scheme proposed by Whitbread (1997).

Mineralogical characterization of all pottery and clay samples was performed by Powder X-ray diffraction analysis (PXRD) on a Bruker D8 advance diffractometer, with Cu Kα radiation. X-ray diffraction patterns were taken in the range 5°–60° 2θ, with steps of 0.02° 2θ and step-times of 1 s/step.

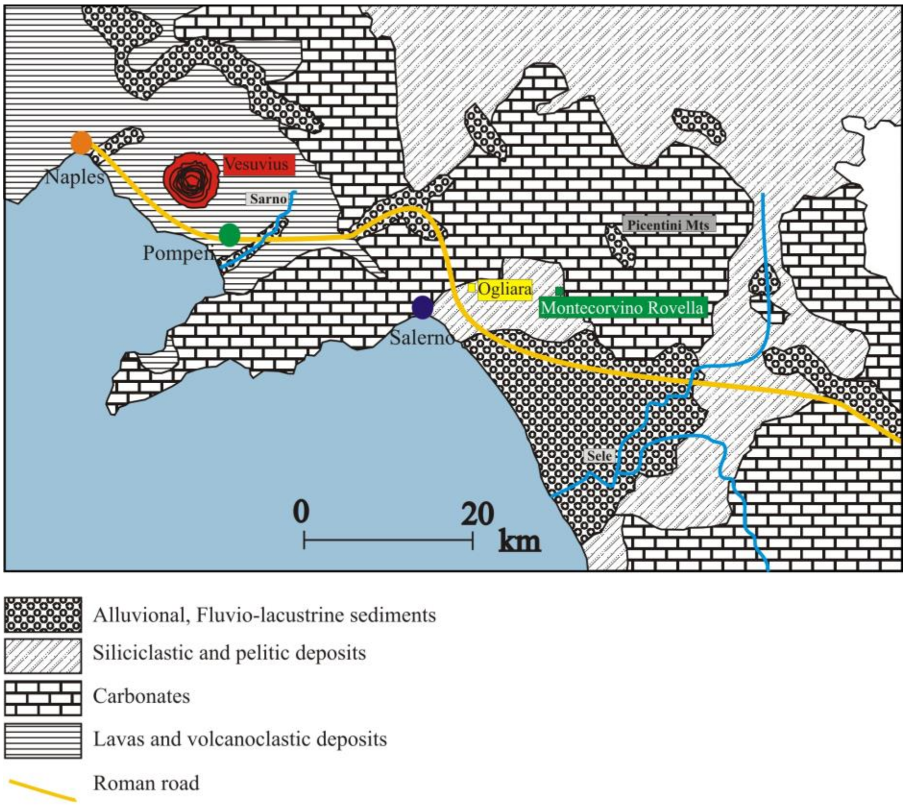

Figure 2. Simplified geological map of the Campania (Modified by De Bonis et al., 2013). Location of the clayey sediment outcrops in Salerno province.

The chemical composition, in terms of major, minor and some trace elements, was determined on pressed powder pellets by X-ray fluorescence spectroscopy (XRF) on a Bruker S8 Tiger spectrometer. The pellets were prepared with an aliquot of approximately 5g of powdered material from ceramic body (previously stripped of the black glaze and milled in an agate mortar), on a support of ultra-pure boric acid, after having been pressed with a hydraulic press. The detection limit for major element oxides was 0.01 wt% and for trace elements about 10 ppm. The accuracy was checked through two international standards (AGV-1 of USGS-USA and NIM-G of NIM-South Africa). Loss on ignition (LOI) was estimated gravimetrically after overnight heating at 950 °C.

Grain size analyses were conducted on clay samples by the wet method and standard sieves for the determination of the > 74 µm fraction. The passing fraction was complementarily analyzed by means of a sedimentation technique, allowing the evaluation of the fraction passing 2 µm. In order to calculate the particle size via sedimentation, the specific gravity of the solid particles was previously determined by the Gay Lussac pycnometer procedure.

Samples of experimental fired clay were prepared in order to perform a petrographic comparison with analyzed ceramics. Considering the homogeneity of the composition of Ogliara and Montecorvino Rovella samples, only two test specimens were prepared using the OGL_2 representative sample (size 5x3x0.5 cm). The clayey samples were fired at two different temperatures at 900 °C and 1100 °C in an electric kiln, exposed to the maximum temperature for 3h and then cooled for about 12 h in the same kiln.

Subsequently, thin sections were prepared and analyzed by optical microscopy.

5. RESULTS

5.1 Ceramics: petrographic, mineralogical and chemical analyses

Optical microscopy on the selected new five ceramics confirmed the petrographic features shown in

Scarpelli *et al.* (2014). A very fine fabric with non-plastic inclusions shows a maximum grain size of 0.15 mm for ceramic sherds (Fig. 3). These are represented by microcrystalline quartz, plagioclase, rare white mica and opaque oxides. Calcite was mainly found as fine microcrystalline grains scattered in a clay matrix or concentrated in the pores. Rare are the remains of microfossils and absent are any volcanic rock grains.

PXRD data show the presence of quartz, hematite, anorthite, wollastonite, diopside and gehlenite in all samples analysed. The presence of neo-formed minerals such as diopside, wollastonite and gehlenite confirms that the firing temperature is above 1000 °C (Riccardi *et al.*, 1999, Cultrone *et al.*, 2001; Grifa *et al.*, 2009; Rathossi and Pontikes, 2010; Maggetti *et al.*, 2011) as already observed by Scarpelli *et al.*, (2014). However, since the ancient ceramics have been exposed also to reducing conditions during firing (3-stage firing - oxidizing, reducing, oxidizing), the formation of these mineral phases could be achieved at lower temperature (Maniatis *et al.*, 1983).

Major, minor and trace element concentrations (from XRF analyses) on the Pompeii ceramics are shown in Table II. Average concentrations from previous analyses of other Black Glazed pottery sherds in Pompeii (Scarpelli *et al.*, 2014) are also indicated.

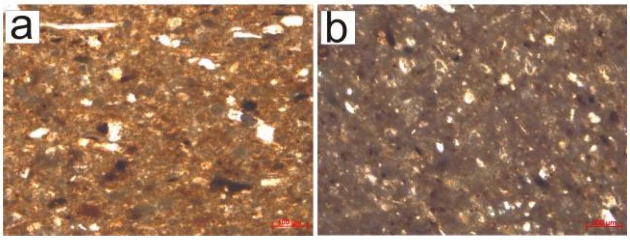

Figure 3. Micrographs of the selected analyzed samples: a) VL8 sample; b) VL11 sample

5.2 Clayey sediments: petrographic, mineralogical, chemical and grain size analyses

XRD data on the clay samples show the marked homogeneity of the mineralogical composition in sediments from Ogliara and Montecorvino Rovella. Quartz is always the most abundant phase, followed by calcite, chlorite, micas and feldspars. Variable amounts of dolomite in all samples were also identified (Tab. III).

Table II. XRF (X-ray Fluorescence) results on the ceramic body of the Black Glazed ceramics from Pompeii. Major elements are listed in weight percent (%), trace elements (Ni to Pb) in parts per million (ppm). Mean and standard deviations of Scarpelli et al.(2014) are included.

								Scarpelli et al., 2014
	VL8	***VL9***	***VL11***	***VL13***	***VL14***	***Mean***	***St.Dev***	***Mean (n=15)***
SiO_2	56.97	56.13	57.65	54	57.23	56.40	1.45	*56.1±0.7*
Al_2O_3	15.37	16.19	16.87	18.15	16.24	16.56	1.03	*16.3±0.8*
Fe_2O_3	6.78	6.84	7.69	6.76	6.92	7.00	0.39	*7.0±0.2*
MnO	0.12	0.09	0.12	0.06	0.1	0.10	0.02	*0.11±0.02*
MgO	4	3.03	2.92	3.26	3.98	3.44	0.52	*3.56±0.17*
CaO	11.96	12.97	9.59	12.85	10.62	11.60	1.46	*12±1*
Na_2O	0.72	0.48	0.54	0.6	0.63	0.59	0.09	*0.6±0.2*
K_2O	3.04	3.08	3.33	2.65	3.11	3.04	0.25	*3.11±0.23*
TiO_2	0.77	0.8	0.86	0.96	0.81	0.84	0.07	*0.82±0.03*
P_2O_5	0.27	0.39	0.42	0.71	0.35	0.43	0.17	*0.46±0.11*
Ni	58	53	74	58	66	61.80	8.26	*60.5±3.8*
Cr	135	146	158	182	158	156	17	*155±13*
V	123	143	147	159	131	141	14	*149±18*
La	29	31	44	45	45	38.80	8.07	*53.3±4.5*
Ce	70	68	83	82	73	75.20	6.91	*71.13±8.15*
Co	17	11	17	15	21	16.20	3.63	*16.4±2.1*
Ba	398	334	417	322	388	372	42	*326±33*
Nb	16	16	18	19	16	17.00	1.41	*16.07±1.53*
Y	26	23	28	24	27	25.60	2.07	*25.2±1.6*
Sr	378	409	353	441	372	391	35	*474±58*
Zr	144	108	144	135	134	133	15	*131±10*
Cu	21	12	27	21	20	20.20	5.36	*26.13±10.99*
Zn	108	93	108	94	107	102	8	*111±5*
Rb	143	131	155	143	135	141	9	*146±15*
Pb	16	18	20	18	23	19.00	2.65	*18.8±7.2*

Table III. Mineralogical phases and relative abundances identified by XRD analysis of Salerno clays: xxxx=very abundant; xxx=abundant; xx=present; x=scarce; tr=traces.

	Quartz	*Calcite*	*Chlorite*	*Micas*	*Feldspars*	*Dolomite*
Ogliara						
OGL_1	xxxx	xxx	x	x	x	tr
OGL_2	xxxx	xxx	xx	xx	x	tr
OGL_3	xxxx	xxx	xx	xx	x	tr
OGL_4	xxxx	xxx	xx	xx	x	tr
OGL_5	xxxx	xxx	xx	xx	x	tr
Montecorvino Rovella						
MCV_1	xxxx	xxx	xx	xx	x	tr
MC2_1	xxxx	xxx	xx	xx	x	tr
MC2_2	xxxx	xxx	xx	xx	x	tr
MC2_3	xxxx	xxx	xx	xx	x	tr
MC2_4	xxxx	xxx	x	x	x	tr

Table IV shows the concentrations of the major (in weight %) and of trace elements (in ppm) in the clay materials. Close compositional similarity was observed between samples from the two considered outcrops.

Grain size analyses, performed on eight representative samples (four from Montecorvino Rovella and four from Ogliara outcrops), showed quite homogeneous particle-size distribution (Tab. V)

Table IV. Concentrations of the major (%) and the trace elements (ppm) obtained by XRF analyses of Mio-Pliocene clay sediments from Salerno outcrops .

	OGL_1	***OGL_2***	***OGL_3***	***OGL_4***	***OGL_5***	***MCV_1***	***MC2_1***	***MC2_2***	***MC2_3***	***MC2_4***
SiO_2	54.97	55.03	55.79	52.83	53.48	54.69	52.43	53.69	53.6	54.02
Al_2O_3	15.84	15.83	17.26	15.57	15.89	16.34	15.26	15.97	15.98	15.51
Fe_2O_3	6.68	6.9	6.43	7.26	7.1	6.58	6.85	6.82	6.88	6.64
MnO	0.08	0.09	0.06	0.12	0.1	0.09	0.12	0.1	0.1	0.09
MgO	3.6	3.5	3.52	3.48	3.7	3.75	3.65	3.65	3.52	3.65
CaO	14.7	14.55	12.47	16.17	15.38	14.08	17.59	15.43	15.57	15.78
Na_2O	0.39	0.4	0.33	0.78	0.47	0.51	0.48	0.55	0.52	0.52
K_2O	2.75	2.7	3.11	2.79	2.89	2.96	2.64	2.8	2.83	2.82
TiO_2	0.83	0.82	0.86	0.8	0.81	0.82	0.79	0.82	0.82	0.79
P_2O_5	0.16	0.18	0.17	0.2	0.17	0.17	0.19	0.17	0.18	0.18
Ni	46	45	56	58	61	65	49	63	53	57
Cr	121	128	153	140	137	144	131	137	134	141
V	158	163	177	168	170	167	146	153	152	142
La	34	37	36	34	30	38	41	42	40	21
Ce	65	64	65	65	68	69	61	62	56	60
Co	15	16	15	18	21	17	13	17	16	17
Ba	240	223	263	213	204	248	232	245	257	275
Nb	14	14	15	14	14	14	13	14	14	13
Y	26	26	27	25	26	26	26	26	27	26
Sr	460	476	475	639	547	507	637	571	591	608
Zr	127	128	123	120	120	128	127	128	129	130
Cu	25	26	30	31	27	24	29	29	29	33
Zn	100	104	115	106	108	111	97	105	106	109
Rb	130	126	148	134	137	138	122	132	130	132
Pb	19	17	19	20	20	16	16	17	18	16

Table V. Grain-size results in percent (%) on the Ogliara and Montecorvino Rovella outcrops.

Sample	*Sand*	*Silt*	*Clay*
Ogliara			
OGL_1	16	56	28
OGL_2	12	52	36
OGL_3	3	56	41
OGL_5	7	48	45
Montecorvino Rovella			
MCV_1	3	44	53
MC2_2	7	54	39
MC2_3	11	58	31
MC2_4	5	58	37

Silt (2< ϕ <63 μm) was the most abundant fraction in all samples (from 58% to 44%). The MCV_1 sample showed a greater content of clay fraction (53%).

According to Shepard (1954), all samples can be classified as "clayey silt", while MCV_1 as "silty clay". No grain-size distinction has been observed between the clays sampled in Montecorvino Rovella and Ogliara outcrops.

The petrographic analysis of the two fired test specimens of OGL-2 clay sample, shows the presence of very few micro voids, but fewer in the sample fired at 1100 °C (Fig. 4). The packing is very spaced and the distribution of the aplastic fraction is approximately 4% for the sample fired at 900 °C (Fig. 4a). The matrix appears homogeneous and reddish brown in colour for the sample at 900 °C, but yellow-green for that at 1100 °C (Fig. 4b). Both are optically negative. The aplastic fraction shows maximum grain size of 0.15 mm and is composed of quartz, feldspars, rare white mica, opaque oxides and remains of microfossils (Fig. 4a). In the sample at 1100 °C only quartz and feldspars are recognized (Fig. 4b).

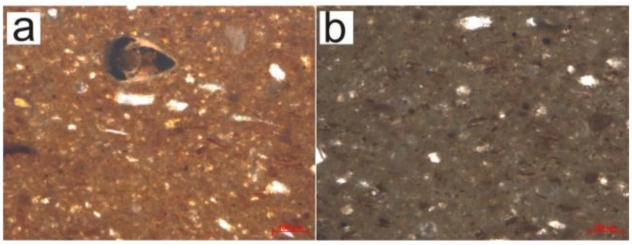

Figure 4. Thin-section microphotographs of two fired clay test specimens. a) Fired test specimen at 900 °C; b) Fired test specimen at 1100°C.

6. DISCUSSION

The analyses performed on the clayey materials collected in the Salerno area provide much evidence for compatibility in the compositions of sediments and the Black Glazed ceramics.

Fig. 5 shows a petrographic comparison between a clayey test specimen fired at 900 °C and two representative ceramic sherds. The fired specimen evidenced a similar simple petrographic and mineralogical composition of the analysed ceramics in particular for the presence of quartz, plagioclase and micas but also of remains of microfossils. The grain size distribution of the aplastic inclusions is highly compatible. However, the higher percentage of remains of microfossils in the fired clay, corroborates the possible levigation of the raw materials before the production of the ceramics.

Anyway the geochemical data obtained from XRF analysis was very useful in this study allowing to make a comparison between ceramics and clays and to test the local provenance and the possible use of Salerno clays for the production of the Black Glazed pottery from Pompeii. The analysed pottery samples are compositionally quite homogeneous, as are the clayey sediments sampled from the Ogliara and Montecorvino Rovella sites.

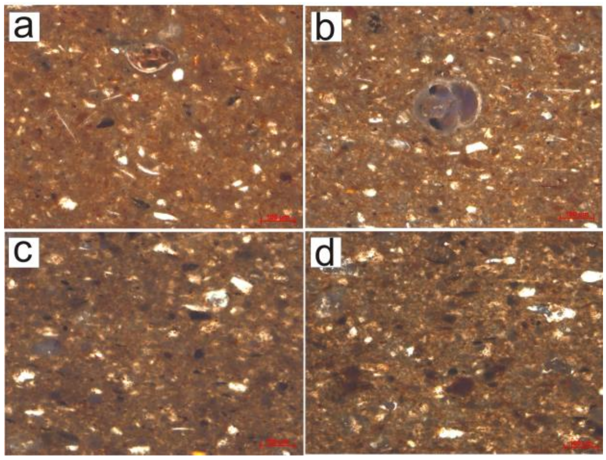

Figure 5. Petrographic comparison between fired clay test specimen at 900 °C (a-b) and the analysed ceramics (c-d).

Comparisons by binary diagrams (Fig. 6) between analysed ceramics, potsherds previously investigated by Scarpelli *et al.* (2014) and Salerno clays, showed a great compatibility among ceramics and clays for both selected major oxides (SiO_2, Al_2O_3, Fe_2O_3- Fig. 6a-b) and trace elements (Ni, Cr, Zr, V- Fig. 6c-d).

A slight difference was observed in the SiO_2 vs. CaO plot (Fig. 6a) in which a higher content of CaO (average 15%) characterizes the clays than the ceramics (average 12%).

This may be due to the refinement of the raw material from impurities including fossils that would explain the indirect decrease of calcium and enrichment of silica contents in the ceramics produced (Kilikoglou *et al.*, 1988; Fabbri, 1996). This suggestion was confirmed by petrographic analysis (Fig. 5) and also by trace element contents, particularly important in studies of provenance (Hein *et al.*, 2004). The Fig. 6c and Fig. 6d show that minimal variations of the selected trace elements (Ni, Cr, Zr and V) are observed with respect to the considered clays.

The variations of the chemical composition of the ceramics are insignificant and not necessarily related to use of different raw materials. The data are also partially compatible with those provided by De Bonis *et al.* (2013) related to different clayey sediments (HCC- high-CaO, and LCC-low CaO content) from the Campania region. In the present work, only the youngest, predominantly carbonate-bearing sediments (Miocene-Pleistocene) and with a variable high-CaO content, were considered.

The Principal Component Analysis (PCA) clearly put in evidence the great similarity of the Black Glazed pottery from Pompeii and the Salerno clays analysed here, on the basis of selected major and trace elements SiO_2, Na_2O, TiO_2, Fe_2O_3, K_2O, MnO, Al_2O_3, Zr, Sr, Nb, Cr, Rb, Y and Ni (Fig.7).

The few samples by De Bonis *et al.* (2013) (RUF 2 – AIL1 – CVR1) that showed a great compatibility with studied clays and ceramics, belong to the Salerno-Montecorvino Basin Unit (Pappone *et al.*, 2010) and to the Pietraroja formation (Bonardi *et al.*, 2009; Vitale and Ciarcia, 2013).

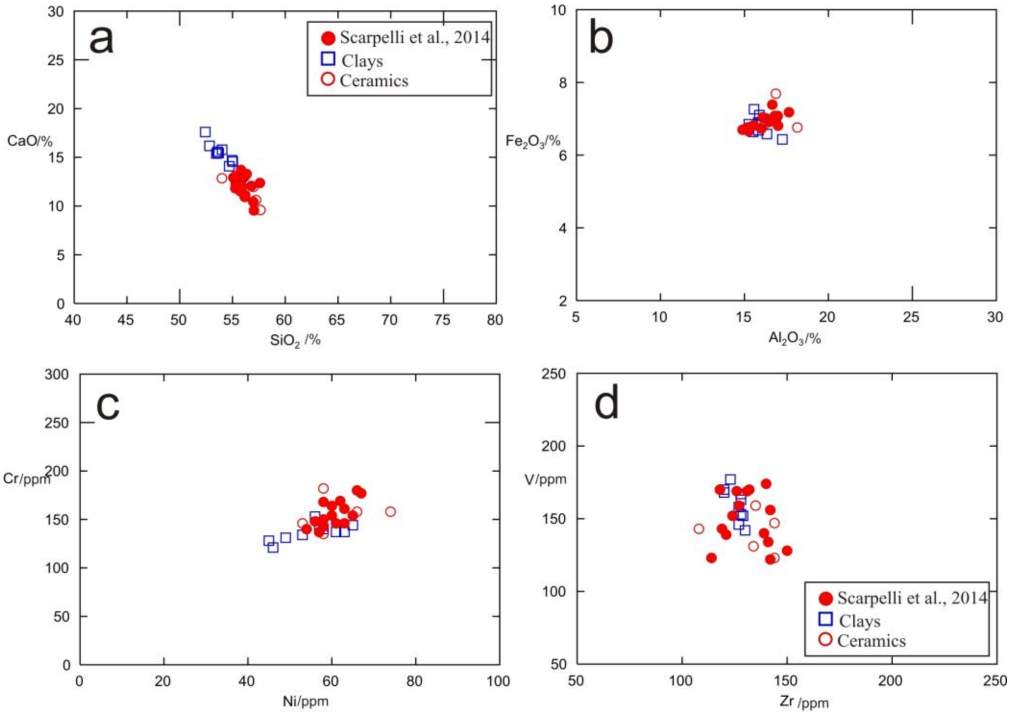

Figure 6. Comparison between Black Glazed pottery and clays from Salerno. Binary diagrams. a) SiO_2 vs. CaO; b) Al_2O_3 vs. Fe_2O_3; c) Ni vs Cr; d) Zr vs.V

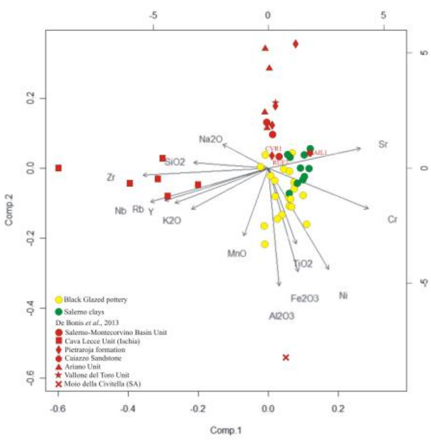

Figure 7. PCA analysis performed considering the first two principal components and using R-studio software for calculations

The samples from the island of Ischia (on the left of Fig.7) show different chemical composition because they represent a mixture of sediments from two different sources: a volcanic component and a siliciclastic component as evidenced by lower CaO and Sr contents and higher Rb, Zr, and Nb contents with respect to the other HCC basinal deposits (De Bonis, *et al.*, 2013).

The other clayey sediments analyzed by De Bonis, *et al.* (2013), are different, in particular with respect to their lower Al_2O_3 and Fe_2O_3 contents.

To detect if the principal component varies between the three groups, the non-parametric Mann-Whitney test was used. The test allowed assessment of the significant differences between the medians of three considered groups, using a threshold for significance of 0.05. If $p < 0.05$, differences were considered statistically significant.

No significant difference in the first component occurred between Salerno clays and Black glazed pottery (p=0.90) whereas PC1 was statistically different for samples collected by De Bonis *et al.* (2013) compared to those collected by other groups (p=0.00).

7. CONCLUSIONS

The combined petrographic and chemical analyses performed on the Black Glazed pottery (ceramic body) from Pompeii and the possible raw materials from Salerno, provided significant information about the production area.

Petrographic thin-section study carried out by comparison of fired clay specimens and ancient ceramics has revealed the presence of the same aplastic inclusions characterized by quartz, feldspars and microfossils and similar grain size distribution.

The statistical approach to the chemical data by XRF analysis on ceramics from Pompeii and Salerno clays allowed to confirm their similarity as regards both major and trace elements supported also by comparison with bibliographic data. In particular the Mio-Pliocene sediments from the Salerno-Montecorvino Basin Unit, represent the more compatible clays for the production of Black Glazed pottery.

It is not excluded that other similar raw materials from the Campanian area could have been employed for the production of Black Glazed pottery from Pompeii, since few other such studies have yet been made. A more detailed sampling and analyses of the other potential clayey raw materials of the region will be necessary to confirm these conclusions.

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