"Pantellerian Ware" from Miseno (Campi Flegrei, Naples)

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ABSTRACT. — Samples of cooking ware from the Sacello degli Augustali, a worship place of the ancient Misenum, were investigated from an archaeometric point of view. On typological basis (shape, accurate polished surface, typical volcanic inclusions) some of them were considered as belonging to the so-called «Pantellerian Ware». The petrographical and mineralogical study allowed to identify three groups characterized by different volcanic temper. Six samples instead of four were attributed to Pantellerian Ware due to the occurrence of phases typical of magmatic evolved peralkaline rocks. A second group was identified for the presence of a volcanic temper typical of calcalkaline rocks and tentatively assigned to an Aeolian provenance. The third group shows abundant trachytic and leucititic rock fragments and likely represents a local production.

It is remarked the good technological properties of the cooking ware from Pantelleria due to the use of abundant and well sorted temper, non calcareous clays and low firing temperatures that provide the manifact a low dilation coefficient and good resistance to strong thermal shocks. These features along with a well standardized manufacture that makes these potteries suitable to be transported, allowed to achieve a large diffusion of the «Pantellerian Ware» within the Mediterranean Sea, from the African through the Spanish coasts, and in the Gulf of Naples and Pozzuoli.

RIASSUNTO. — Sono state condotte analisi archeometriche su dieci campioni di ceramica comune da fuoco, provenienti dal Sacello degli Augustali, un antico luogo di culto dell’antica Misenum. Sulla base dei dati tipologici (forma, superficie esterna stecata e tipici inclusi vulcanici) alcuni di questi campioni vengono considerati come appartenenti alla ceramica da fuoco da Panteleia (Pantellerian Ware). Le osservazioni mineralogiche e petrografiche hanno permesso di identificare tre gruppi caratterizzati da differente smagianto vulcanico. Sei campioni sono stati attribuiti alla Pantellerian Ware in base al contenuto di fasi mineralogiche tipiche di rocce evolute a carattere peralcalino. Un secondo gruppo è stato identificato per la presenza di inclusi vulcanici tipici di rocce calcalkaline ed è stata ipotizzata una provenienza eoliana. Infine, è stato riconosciuto un terzo gruppo di produzione locale, caratterizzato dalla presenza di abbondanti frammenti di rocce trachitiche e leucitiche.

La ceramica comune da fuoco da Panteleia mostra delle buone proprietà tecnologiche, dovute all’utilizzo di smagianti ben calibrati di grosse dimensioni, argille non calcaree, e basse temperature di cottura che garantiscono al manufatto un basso coefficiente di dilatazione e una buona resistenza agli shock termici. Le forme ben standardizzate dei
INTRODUCTION

The Sacello degli Augustali is one of the most representative monuments of the ancient Miseno (Campi Flegrei), a military harbour of Imperial Age. Due to its strategical position in the Gulf of Naples and a favourable morphological site, Misenum (from the trumpeter of Enea drowe in those waters) was founded in the IV century B.C. by Greek settlers and soon appointed as fundamental support of the defensive system of Cuma. Afterward the devastating transit of Hannibal, the restoration of the Misenum territory was mainly devoted to the construction of luxury buildings and villas.

Starting from the I century A.D., under the Empire of Augustus Misenum got back its role of strategical and military area. A harbour was built where the Classis Praetoria, a powerful fleet under the direct control of the Emperor, set up (Miniero, 2000a).

The Misenum harbour was constituted by two natural basins: the inner one corresponding to the current Miseno lake, also used as shipyard; the external one, the Miseno Bay, was the real harbour. They were connected by an artificial channel, today silted up, whereas the entrance to the harbour was protected by two piers on arcades, extensions of two natural bastions, Punta Terone and Punta Pennata, that represent the remnants of the border of Porto Miseno tuff ring (Inginga et al., 2002 Inisinga, 2003, Fig. 1).

With the only exception of a short wartime (68-69 A.D.) in the ligurian gulf, the Misenum fleet was inactive for many centuries with the only aim to serve the members of the imperial family. The presence of the Classis Praetoria, a personal tool of power for the emperor, made Misenum a sort of domain of the imperial family. Within this framework the Sacello represented an important place of worship, where the Augustales accomplished rites, played games and attended ceremonies in honour of the divinised emperors and in suffrage of the genius or numen of the emperor in charge. The Sacello degli Augustali is one of the best preserved monuments of the old Misenum Forum (Fig. 2), found during the excavation of 1967 (Miniero, 2000b). This complex (Fig. 3) is constituted by a central and two lateral rooms opening on an arcade courtyard where a cipolline marble columns tetrastyle pronao was erected and that supported the epistyle with the dedicatory inscription and the decorated pediment.

The whole settlement was buried under a thick cover of pyroclastic products mainly deriving from the reworked materials of Miseno Tuff Cone (Inisinga et al., 2002; Inisinga, 2003; Inisinga et al., 2004).

After its abandonment the Sacello was used as dump area where coarse, fine and even cooking wares, the latter object of the present research, have been found.

The scarce attention devoted to the archaeological and volcanological stratigraphy during the excavation did not allow to reconstruct the modality and the time of deposition of these materials, with loss of precious data necessary to interpret the material culture, reflection of the activities and life conditions in the Gulf of Pozzuoli.

On this regard, some useful considerations can be drawn by carefully taking into account the rims counting of the «Terra Sigillata» (Fig. 4) between the 180/200 and the 660/680 A.D. Two important dumping periods can be likely identified: a first one between the 200/220 A.D. and 240/260 A.D. and a second one between the 320/340 A.D. and 400/420 A.D. From this last period on the rims of «Terra Sigillata» start to lose their value, even if they maintain
Fig. 1 – Schematic geological map of Miseno area (Modified after Inginga, 2003):

some relevance until 480 A.D. From that time on, refuse materials have been continuously dumped, but the current knowledge does not enable to state whether the reduced amount of *Terra Sigillata* derives from a decrease of the dumping activity in the *Sacello* area or it witnesses a drastic reduction of African tableware importation within the Phlaegrean area.

Among the cooking ware, a small group of fragments has been identified as belonging to the Pantellerian ware due to their workmanship and shaping (Santoro Bianchi and Guiducci, 2001; Santoro Bianchi, 2002 and references
Fig. 2 – Archaeological map of Misenum. Arrow indicates the location of the Sacello degli Augustali.

Fig. 3 – Schematic plan of the Sacello.

Fig. 4 – Rims counting of the Terra Sigillata in the Sacello degli Augustali excavation (Soricelli, 2000)
samples and methods

Table 1 reports for all the investigated samples typological information and the presumed provenance on the basis of archaeological observations (Soricelli, 2000).

Table 1

Cooking ware samples from the Sacello degli Augustali

<table>
<thead>
<tr>
<th>Sample</th>
<th>Typology</th>
<th>Presumed provenance*</th>
<th>Chronology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Saucepan</td>
<td>Pantelleria</td>
<td>IV-V century A.D.</td>
</tr>
<tr>
<td>2</td>
<td>Saucepan or dish</td>
<td>Pantelleria</td>
<td>IV-VI century A.D.</td>
</tr>
<tr>
<td>3</td>
<td>Saucepan or dish</td>
<td>Pantelleria</td>
<td>IV-VI century A.D.</td>
</tr>
<tr>
<td>4</td>
<td>Casserole</td>
<td>Local</td>
<td>V-VIII century A.D.</td>
</tr>
<tr>
<td>5</td>
<td>Casserole</td>
<td>Local</td>
<td>IV-VII century A.D.</td>
</tr>
<tr>
<td>6</td>
<td>Saucepan</td>
<td>Pantelleria</td>
<td>V century A.D.</td>
</tr>
<tr>
<td>7</td>
<td>Saucepan</td>
<td>Local</td>
<td>V century A.D.</td>
</tr>
<tr>
<td>8</td>
<td>Saucepan</td>
<td>Local</td>
<td>V century A.D.</td>
</tr>
<tr>
<td>9</td>
<td>Lid</td>
<td>Local</td>
<td>IV-VII century A.D.</td>
</tr>
<tr>
<td>10</td>
<td>Casserole</td>
<td>Local</td>
<td>V-VIII century A.D.</td>
</tr>
</tbody>
</table>

* The presumed provenance is based on morphological and macroscopic observation (Soricelli, 2000).
Fig. 5 – Drawings representing the main shapes of cooking ware from the Sacello degli Augustali (Soricelli, 2000); a) Saucepan; b) Saucepan or dish; c) Saucepan or dish; d) Saucepan, e) Casserole; f) Casserole, g) Saucepan.
investigate the microstructures and to evaluate the degree of vitrification of the clay matrix.

The distribution of the pore access size, as well as the pore volume were determined by Mercury Intrusion Porosimetry (MIP) on freshly cut sherd of about 2 cm³ with a Thermo Finnigan Pascal 140 porosimeter (range = 0.1-400 kPa; pressure resolution 0.1 up to 400 kPa; accuracy = higher than 0.25%; pore range size measure = 1.900-58.000 μm; volume pore field measure = 0.1-500 μm³) and a Pascal 240 porosimeter (range = 0.1-200 MPa; pressure resolution 0.01 up to 100MPa, 0.1 up to 200MPa; volume resolution 0.1 mm³; accuracy = higher than 0.2%; pore range size measure = 3.7-7500 μm; volume pore field measure = 0.1-500 mm³).

ANALYTICAL RESULTS

Petrographic studies

The petrographical study evidences the optical features of the thin section in terms of colour, optical activity of the matrix, packing, sorting, distribution and composition of a-plastic inclusions (Maggetti, 1991). The interpretation of these parameters can provide useful information on the provenance and manufacture of the ceramics materials. For all the samples, in agreement with their prevalent use as cooking ware, the presence of abundant a-plastic inclusions necessary to buffer the clay shrinkage during the firing operation, was pointed out. The concomitant use of moderate firing temperatures (between 750-850°C) enables to produce low stiff structures with a low dilution coefficient α (Olceese and Picon, 1994; Tite et al., 2001).

The following descriptions of the samples grouped on the basis of mineralogical and petrographical observations take into account the international notation of Wentworth scale (Greensmith, 1989) to define the size fraction of the inclusions, the comparative diagrams of Terry and Chilingar (1955) to estimate packing of the a-plastic inclusions.

- Group 1 (samples 2, 3, 6, 7, 8, 9)

The matrix, predominant component of the mixture, is optically isotropic and shows a colour ranging between brown and dark brown. Some portions of the matrix have a darker colour as a possible consequence of the combustion of organic matter added to the mixture. A-plastic inclusions range in size between 1.5 and 2.0 mm (very coarse sand), their packing ranges between 20 and 30 vol% and grains show angular rims (Hodgson, 1974). They represent the remaining portion of the mixture mainly constituted by volcanic materials such as scoriae, pumices (Fig. 5a), obsidian fragments, lithic fragments and crystals.

In order of abundance the following minerals were recognized: anorthoclase, alkali feldspars, aegirine (Fig. 6b) and subordinate quartz, biotite and muscovite. The crystal size distribution is bimodal (ital) and the size of the volcanic matter is larger than the residual crystal (quartz and alkali feldspars, essentially) fraction of the clay.

- Group 2 (samples 1 and 5)

Samples of this group show a darker central body (core) due to reduction conditions settled during the firing operation, with external surfaces light brown coloured, a typical sandwich structure (Letch and Noll, 1983; Harrel and Russel 1967). A-plastic inclusions show a low sorting grade, size ranging from 0.10 mm and to 1.75 mm (very fine sand to very coarse sand, serial texture), a packing of about 30-40 vol% and subangular rims (Hodgson, 1974). Scoriae, pumice and obsidian fragments constitute the volcanic lithics. Carbonate grains sometimes occur as microcrystalline calcite in the pores or indirectly recognizable by casts (pores by marks) related to firing process. The main mineral phases are: quartz (abundant tiny fragments), plagioclase (Fig. 6c), alkali feldspar, biotite, augite (Fig. 6d) and rare brown amphibole.
Fig. 6 – Representative micrographs of thin sections. a) Group 1. Large pumice with a small aegirine crystal in the lower right portion (Plane polarized light); b) Group 1. Large green aegirine crystal (Plane polarized light); c) Group 2. Dusty plagioclase (Crossed polars); d) Group 2. Pumice, augite, and plagioclase (Plane polarized light); e) Group 3. Trachytic scoria (Crossed polars); f) Group 3. Large diopside crystal (Crossed polars).
• Group 3 (samples 4 and 10)

The matrix is optically inactive and shows a colour ranging from brown to dark brown; a low compact structure is characterized by frequent voids and fractures. The a-plastic inclusions with a serial grain distribution (0.2–1.0 mm, fine to coarse sand), packing ranging from 20 to 30 vol%, and subangular rims (Hodgson, 1974), are represented by trachytic (Fig. 6e) to leucitic volcanic lithics, pumice, scoriae, crystal fragments and chamotte (particularly abundant in sample 4). Alkali feldspar (sanidine), clinopyroxenes (diopside and salite, Fig. 6f), biotite, white mica (in tiny lamellae as residual mineral of clays), titanite, garnet and quartz (residual mineral of clays), were also recognized.

The petrographical observations allow to draw the following considerations:

– the distinguishing feature of group 1 is represented by the combined occurrence of anorthoclase and aegirine; group 2 is characterized by plagioclase (dusty and patchy-zoning), augite and amphibole, group 3 by trachytic and leucitic lithics, abundant sanidine, diopside, salite and garnet. Within this last group a further distinction should be carried out between the two samples in terms of abundance of components: sample 4 is richer in chamotte and pumice whereas sample 10 displays a higher amount of alkali feldspar.

**XRD analysis**

Mineral assemblages can often provide useful information on the firing process dynamics; the appearance of new formed phases, the loss of others, the persistence of prograde phases may suggest the lowest and the highest temperatures reached during the firing process (e.g. Riccardi et al., 1999).

Table 2 reports the semi-quantitative results of the XRD analyses carried out on the potteries of the Sacello degli Augustali.

All the investigated samples have quartz as common phase, even though, as residual mineral in clays, it is not always detectable on microscope observations. Feldspars are abundant in all the samples, in agreement with the petrographical observations. Pyroxenes are always present showing higher contents in samples 4 and 2. Evidences of residual illite in eight samples out of ten may suggest firing temperatures not exceeding about 850°C, above which this clay mineral undergoes a breakdown. Illite only lacks in samples 1 and 5 that, on the other hand, show calcite in traces. This evidence can be explained by firing temperatures close to 850°C but not as much

<table>
<thead>
<tr>
<th>Sample</th>
<th>Biotite</th>
<th>Feldspars</th>
<th>Quartz</th>
<th>Calcite</th>
<th>Hematite</th>
<th>Clinopyroxene</th>
<th>Illite</th>
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<td>x</td>
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</table>

**Table 2**

*XRD semi-quantitative mineralogical evaluation of the investigated samples.*

*Legend: xxxx=predominant; xxx=abundant; xx=frequent, x=sporadic, tr=traces.*
high to achieve a complete dissociation of calcite; it should be remarked that petrographical observations do not indicate calcite as formed by processes settled after the firing process (i.e. by calcite precipitation after burial).

**XRF analysis**

The bulk chemical analyses of the cooking ware reported in table 3 and carried out by X-ray fluorescence (major elements: Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, P wt% oxides; trace elements: Rb, Sr, Y, Zr, Nb, Sc, V, Cr, Ba ppm) evidence the wide variability of the chemical composition both in terms of major and trace elements.

Variation diagrams always allowed to discriminate at least two different chemical groups (Fig. 7a) one of which perfectly corresponding to the previously identified petrographical group 1. Cooking ware belonging to this group (samples 2, 3, 6, 7, 8, 9) show SiO₂ values ranging between 56.8% and 61.5% (wt % LOI free), higher TiO₂ (1.00 - 1.27 wt%) and Fe₂O₃ (8.54 - 10.8 wt%) contents. As far as trace elements are considered Ba (710 - 957 ppm), Zr (736 - 1195 ppm) and Nb (144 - 264 ppm) turned out particularly concentrated.

Group 2 (samples 1 and 5) shows generally high SiO₂ values (65.78 and 61.10 wt%), low K₂O content and the lowest values for Zr (163-255 ppm) and Nb (19-22 ppm).

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**Fig. 7 -** a) Ba vs Zr (ppm) diagram; b) Rb (ppm) vs Zr/Y ratio diagram; c) Zr vs Nb (ppm) diagram; d) Rb/Nb vs Zr/Y ratios diagram. The dashed area in c) and d) represents the compositional range of some Pantelleria vulcanites (Civetta *et al.*, 1988 and references therein).
Table 3

XRF analyses of the cooking ware from the Sacello degli Augustali.

<table>
<thead>
<tr>
<th>wt%</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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<tbody>
<tr>
<td>SiO₂</td>
<td>65.78</td>
<td>56.81</td>
<td>61.55</td>
<td>54.36</td>
<td>61.10</td>
<td>59.29</td>
<td>59.51</td>
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<td>TiO₂</td>
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<td>1.14b</td>
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<td>0.79</td>
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<td>23.17</td>
<td>18.15</td>
<td>24.92</td>
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<td>19.71</td>
<td>18.17</td>
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<td>Fe₂O₃</td>
<td>5.11</td>
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<td>9.52</td>
<td>7.69</td>
<td>6.58</td>
<td>10.81</td>
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<td>9.92</td>
<td>8.54</td>
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<td>MnO</td>
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<td>MgO</td>
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<td>1.81</td>
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<td>Na₂O</td>
<td>1.67</td>
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<td>P₂O₅</td>
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<td>LOI</td>
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</tr>
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</table>

Group 3 (samples 4 and 10) is characterized by the lowest SiO₂ (54.4 and 54.8 wt%) and the highest Al₂O₃ values (24.9 and 26.6 wt%). The peculiar abundance of sanidine in sample 10 also accounts for the highest K₂O content; furthermore, Rb displays the highest values for both samples (263-298 ppm; figure 7b).

Finally, as far as calcium oxide is concerned, its values ranging for all the samples between 1.19 and 3.41 wt%, confirm the non-calcareous character (CaO<7-8 wt% for Olcese e Picon, 1994 and CaO<5 wt% for Tite and Maniatis, 1975) of the clay used for the mixture.

Scanning electron microscopy (SEM)

Scanning electron microscopy is generally used to evaluate the micromorphology of the body of the pottery. This observation may provide useful information on the degree of vitrification of the clay matrix thus suggesting the possible firing temperature of the cooking ware (Kilikoglou, 1994, Tite and Maniatis, 1981).

Micrographs of figure 8 are representative of the analysed samples.

The upper portion of figure 8a (sample 2) shows a still preserved laminar structure of a phyllosilicate exfoliated along basal planes, most probably due to dehydroxylation (Cultrone et al. 2001). The lower portion of the same micrograph shows the fired clay matrix.

The detail of figure 8b (sample 9) evidences an initial stage of vitrification in the clay matrix with diffuse welding of clay particles and smoothed and deformed edges of phyllosilicates (Maniatis and Tite, 1981).

Figure 8c (sample 5) witnesses the continuous vitrification of clay matrix where fine bloating pores appear (Maniatis and Tite 1981). The welding of the particles is here extensive.
Fig. 8 – SEM micrographs; a) sample 2, laminar structure of a phyllosilicate and clay matrix; b) sample 9, Initial Vitrification of the clay matrix (Maniatis and Tite, 1981); c) sample 5, Continuous Vitrification (Maniatis and Tite, 1981).
Table 4 summarizes some technological features of the investigated cooking ware that take into account the interpretation of the SEM observations, mineralogical and textural data and CaO content.

The sherds show a non-calcareous character and, on the basis of the colour of the paste, were fired in conditions of oxidizing atmosphere. The only exception is for samples 1 and 5 manufactured under reducing atmosphere at the body and oxidizing condition at the slip.

The vitrification stage evaluated by scanning electron microscopy was defined as Initial Vitrification (Tite and Maniatis, 1975) for samples 2, 3, 4, 6, 7, 8, 9, 10; the remaining samples (1 and 5) show a Continuous Vitrification with Fine Bloating (Tite and Maniatis, 1975). Thus, the inferred firing temperatures for samples 1 and 5 (petrographic group 2) are between 850°-900°C, and for all remaining samples between 800°-850°C.

Mercury intrusion porosimetry (MIP)

The porosity and in particular the pore-size distribution (PSD) have been considered as a key parameter for predicting technological features of pottery; in fact, these physical parameters play a fundamental role on thermal shock resistance of the cooking ware.

The results of this test confirm the occurrence of three different groups each characterized by a peculiar behaviour (Fig. 9). The pore size radii for samples of group 1 (Fig. 9a) display a quite regular and uniform distribution above the entire investigated range (\(\sim 58 \mu m - 0.004 \mu m\)) with a very slight increase of frequency towards the finest pores. This situation is strongly enhanced in samples of group 3 (Fig. 9c) where the highest frequency falls within the pore range 0.02 – 0.004 \(\mu m\). A completely different pattern was finally recorded for samples of group 2 (Fig. 9b). Here the most represented pore size radii are drastically shifted towards the highest values (\(\sim 0.8 \mu m - 7 \mu m\)) (Cultrone et al., 2004).

DISCUSSION AND CONCLUSIONS

The mineralogical, petrographical and geochemical data allow to univocally identify three groups of samples; the technological features of this specific type of ceramics were also verified. In fact, cooking ware are required to stand high thermal shocks, namely the different temperatures settled between the internal portion of the manufact and the external one exposed to the fire. This thermal difference establishes a differential dilation between the two portions thus generating

<table>
<thead>
<tr>
<th>Sample</th>
<th>Clay type</th>
<th>Atmosphere</th>
<th>Vitrification stage</th>
<th>Firing temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NC</td>
<td>R</td>
<td>CV (FB)</td>
<td>850-900</td>
</tr>
<tr>
<td>2</td>
<td>NC</td>
<td>O</td>
<td>IV</td>
<td>800-850</td>
</tr>
<tr>
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<td>NC</td>
<td>O</td>
<td>IV</td>
<td>800-850</td>
</tr>
<tr>
<td>4</td>
<td>NC</td>
<td>O</td>
<td>IV</td>
<td>800-850</td>
</tr>
<tr>
<td>5</td>
<td>NC</td>
<td>R</td>
<td>CV (FB)</td>
<td>850-900</td>
</tr>
<tr>
<td>6</td>
<td>NC</td>
<td>O</td>
<td>IV</td>
<td>800-850</td>
</tr>
<tr>
<td>7</td>
<td>NC</td>
<td>O</td>
<td>IV</td>
<td>800-850</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
<td>O</td>
<td>IV</td>
<td>800-850</td>
</tr>
<tr>
<td>9</td>
<td>NC</td>
<td>O</td>
<td>IV</td>
<td>800-850</td>
</tr>
<tr>
<td>10</td>
<td>NC</td>
<td>O</td>
<td>IV</td>
<td>800-850</td>
</tr>
</tbody>
</table>

TABLE 4

Hypothesized firing temperature on SEM observation (Maniatis and Tite, 1981).
Fig. 9 – Pore size distribution curves by mercury intrusion. a) sample 3 representative of group 1; b) sample 5 representative of group 2; c) sample 4 representative of group 3.
internal stresses that can damage the pottery. Therefore, a low stiff structure with a low
dilation coefficient $\alpha$ is required. This kind of
structure can be achieved by two different but
complementary methods: a first one consists in
adding to the mixture an abundant fraction of
inert temper, possibly well sorted; the other one
foresees low firing temperatures (between 700
and 800°C) as $\alpha$ is directly related to this
parameter.

Both these two procedures were likely
followed to prepare samples belonging to
group 1, as they show the best technological
features. Samples 1 and 5 (group 2) were fired
at temperatures slightly higher (≈850°C) and
show a low sorted temper. Another feature
worth to be considered is the calcareous or non
calcareous nature of the clay. Non calcareous
clays can give, considering the same dilatation
coefficient ($\alpha$), finer mixtures thus providing a
better wheel workability (Olcse and Picon,
1994). The highest CaO content measured for
the investigated samples was 3.41 wt%.

Petrographical group 1 shows, further than
pumice and volcanic scoriae in the temper,
mineral assemblages typical of differentiated
peralkaline rocks (anorthoclase and aegirine).
The diagram Zr-Nb of Figure 7c compares the
chemical analyses of the studied samples and
peralkaline rocks (pantellerites of the
Pantelleria island). This comparison, justified
by the high content of volcanic temper
reflecting the original composition of the
magma, evidenced that all the samples of
group 1, representative of the Pantellerian
Ware, perfectly overlap the compositional
field of pantelleritic rocks (Ciavetta et al.,
1984; 1988).

In order to minimize problems concerning
absolute concentrations elemental ratios have
also been considered; again, cooking ware from
group 1 show a chemical composition close to
that of pantelleritic rocks (Rb/Zr and Zr/Y
ratios in diagram of Figure 7d).

In summary the whole set of mineralogical,
petrographical and geochemical data confirms
the hypothesis that samples from group 1 come
from the Pantelleria island.

Samples 1 and 5 of group 2 shows a peculiar
mineralogical association, different from all the
others, characterized by plagioclase, augite and
amphibole. The presence of these calcalkaline
magmatism phases (augite and amphibole),
along with dusty and patchy-zoning
plagioclase, leads to put forward a different
origin for these cooking ware. A possible
hypothesis could consider a provenance from
Aeolian islands, a volcanic district
characterized by diffused calcalkaline
magmatism. As far as firing temperatures are
concerned, the absence of any residual illitic
minerals (Table 2) likely indicates slight higher
values if compared to samples of group 1.
Samples of group 3 (4 and 10) are
characterized by an almost different mineral
assemblage: alkali-feldspars (particularly
abundant is sanidine in sample 10), Ca-
pyroxenes (diopside and salite) and garnet. The
concomitant presence of pumice, scoriae and
volcanic lithics with a prevailing trachytic and
subordinate leucitic composition, definitely
allows to attribute to these manufacts a local
provenance (phlegraean and/or vesuvian area).

The Pore Size Distribution analysis also
support the above hypothesis of sample
groupings. In fact, samples of group 2 show the
highest frequency of large pore size (≈ 0.8µ – 7
µ); this feature is in agreement with higher
firing temperatures (850°-900°C), already
hypothesized on the basis of mineralogical and
petrographical data, which are responsible of
an extensive vitrification and welding of the
clay matrix as well as the presence of fine
bloating pores (Maniatis and Tite, 1981). On
the contrary, lower firing temperatures (800°-
850°C) are likely responsible of the different
frequency of pore size distribution (Fig. 9a, c)
for all the other samples (group 1 and 3).

The most meaningful result of the present
study is the ascertained provenance from
Pantelleria of 3 samples formerly supposed to
be of local or regional production (Table 5).
Even if reasonable doubts arise about the
fullness and the coherence of this ceramic
assemblage, the number of Pantellerian ware
found in the Sacello is significant especially if
TABLE 5
Comparison between archaeological (Soricelli, 2000) and archaeometric data (present study).

<table>
<thead>
<tr>
<th>Samples</th>
<th>Archaeological attribution</th>
<th>Archaeometric attribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Pantelleria</td>
<td>Pantelleria</td>
</tr>
<tr>
<td>3</td>
<td>Pantelleria</td>
<td>Pantelleria</td>
</tr>
<tr>
<td>6</td>
<td>Pantelleria</td>
<td>Pantelleria</td>
</tr>
<tr>
<td>7</td>
<td>Local</td>
<td>Pantelleria</td>
</tr>
<tr>
<td>8</td>
<td>Local</td>
<td>Pantelleria</td>
</tr>
<tr>
<td>9</td>
<td>Local</td>
<td>Pantelleria</td>
</tr>
<tr>
<td>4</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>10</td>
<td>Local</td>
<td>Aeolian islands ?</td>
</tr>
<tr>
<td>5</td>
<td>Local</td>
<td>Aeolian islands ?</td>
</tr>
<tr>
<td>1</td>
<td>Pantelleria</td>
<td>Aeolian islands ?</td>
</tr>
</tbody>
</table>

compared to the occurrences in the Gulf of Naples (Grifa et al., 2004) and in the Phaegrean Fields (Carsana, 1994).

Another striking result was the possible aeolian origin of samples 5 and 1 formerly attributed to a local or Pantellerian production, respectively. Aeolian products were already pointed out in the Bay of Naples, where particularly frequent are the «Richborough 527 type» amphorae (Arthur, 1989; 2002) produced in Lipari and mainly used for the alum trade (Bogard, 1994). The wide distribution of the casserole (sample 5), within the Mediterranean area, could possibly be the reflection of the broad diffusion of the «Richborough 527 type» amphorae between the first and fourth century A.D.

In conclusion, archaeometric investigations allowed to distinguish three homogeneous groups of samples:

- **Group 1** (samples 2, 3, 6, 7, 8, 9). Belonging to the Pantellerian Ware typology, produced in Pantelleria between the 1st and the 4th century A.D. It is characterized by abundant and well sorted volcanic temper, typical peralkaline rock phases, and a dark matrix due to the presence of organic matter. This is the most technologically advanced material.
- **Group 2** (samples 1 and 5). This is a peculiar group from a technological point of view. It is in fact characterized by a black body coated by a thin red layer of selected clay fired at temperature higher than 850°C. The mineralogical association of the temper (dusty and patchy-zoning plagioclase, augite, amphibole) leads to hypothesize an Aeolian provenance.
- **Group 3** (samples 4 and 10). These are the only samples of local production as witnessed by the composition of the volcanic temper (diopside-salite, abundant alkali feldspars, trachytic and leucitic rock fragments).

The ceramic potteries belonging to the Pantellerian Ware production (group 1), among all the studied samples best represent technological features of an excellent cooking ware. In fact, the well sorted volcanic temper, the non-calcareous character of the clay, the low firing temperatures, and the standardized shapes suitable for transportation, justify the exportation and the wide distribution in the western Mediterranean basin.

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