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THE SANCTUARY OF HERA AT RIVER SELE MOUTH: NON DESTRUCTIVE ANALYSIS OF ARCHAEOLOGICAL FINDS

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ABSTRACT

"... beyond river Sele mouth, Lucania and the Sanctuary of Argive Hera, settled by Jason and nearby, 50 stadia far, Poseidonia..." (STRABO, Geography, VI, 1, 1). In this way the Greek geographer Strabo, describing the Lucania district, mentions the Sanctuary of Argive Hera at river Sele mouth about 9 km far from Paestum, for many centuries one of the most important religious site in Great Greece.

A first archaeological survey was carried out within the Sele marsh during 1933. After countless vicissitudes mainly due to war and the archaeological findings – not only from Paestum - dispersion occurred during those years, the finds were moved from one place to another, until they reached the new Museum of Paestum storehouse, built in the Fifties.

In 1987, the Archaeological Bureau of Salerno, Avellino and Benevento Provinces with a team of young archaeologists co-ordinated by professor Giovanna Greco from the University of Salerno first and from the University of Naples "Federico II" thereafter started up a new excavation season and a massive rearrangement work of these materials. During the last years a wide scientific publication of such material appeared, also regarding findings from the most recent excavation season, and the archaeological study has been supplemented performing non destructive analysis of findings. These analysis took into account a very large number of fragments for each class of materials, chosen on the basis of an autoptic classification, in order to define, crossing the scientific to archaeological results, the elements marking out the likely local pottery from the, so identified and distinguished, imported objects.

A survey availing of non destructive techniques (mainly transportable EDXRF systems) is being held on pottery and bronzes for the characterization of the technology of production and conservation aspects and chronological and spatial clustering of the pieces.

INTRODUCTION

The study of archaelogical finds coming from the Sanctuary of Hera at river Sele mouth, about 9 km far from Paestum (Salerno), is part of the research project leaded by the University of Naples Federico II in collaboration with the Archaeological Superintendence of Salerno, Avellino and Benevento. Such project, starting again the excavation in 1987 within one of the most important Great Greece sanctuaries, is going to be fulfilled with the publication of the whole scientific results. Therefore, some non destructive analysis of the archaeological finds have supported the traditional way of studying, in order to identify their composition and scientifically verify the nature and origin of basic materials, the manufacturing and cooking procedures, the handiworks function.

This study is part of a wider survey project regarding the Paestan plain clay banks and the basic materials quarrying areas [1], necessary to detect and determine the locally manufactured pottery characteristics.

The analysis have been carried out on a large amount of fragments for each class of materials – Corinthian pottery, Black varnish pottery, Medieval pottery, coroplastic, metals – chosen on the basis of an autoptic classification aiming to a definition of the most important classes and remarkable fragments, in order to identify, crossing the scientific and archaeological results, those elements characterizing the different manufacturing processes, some of them definitely local; so is possible detecting and distinguishing objects from different manufacturing, and then separating those certainly imported.

It has been decided to report here the preliminary results of such survey, particularly highlighting the Corinthian pottery, Medieval pottery and metals; actually these are the first remarks on the carried out work, no longing for completeness but yet providing some interesting hints. As a matter of fact, non destructive analyses availing of Energy Dispersive X Ray Fluorescence were fulfilled on more than 100 pieces of pottery and bronzes coming from the excavation.

The archaeometric studies were divided in 3 main sections: metal, pottery cores and pottery pigments. Belonging to the first group several stannic bronzes were analysed. Belonging to the second group pottery fragments were analysed in order to sample the core of the pieces, that is the inner matrix of the pieces. And belonging to the third group painted surfaces were analysed in order to determine the kind of pigments used.

HISTORY OF THE SITE

On April 9th, 1934 Paola Zancani Montuoro and Umberto Zanotti Bianco discovered the Hera Argiva Sanctuary and gave announcement to the Great Greece Society, funding their research. This sanctuary, founded during the first decades of VI century b.C. by a group of Achaei coming from Sibari, nowadays lies 1500 m far from the river mouth because of those bradyseism phenomena putting the coastal line, within the Paestan plain, about 2 km forward. Probably the area showed all the distinctiveness of a *locus sacer*: the large river was likely navigable, rich in water and marshy vegetation, forming a long and jagged lagoon.

The sacred area started developing around a rough ash altar, a poor structure on which the first sacrifices occurred, sacralizing the area; soon the worship and welcome buildings for pilgrims were organized; and during the first half of VI century an impressive temple was planned, the *hekatompedon*, 100 ft long and 50 ft wide, wonderfully decorated with carved metope and triglyphs.

Probably this first plan was dropped and, by the end of VI century b.C., a huge temple with eight columns on the front was built on more imposing and solid foundations, yet showing a rich and complex stone decoration and two monumental altars, one of which incorporating the older ash altar.

The arrival of Lucanians at the end of V century b.C. brought deep changes; after the final interventions during the Roman age and subsequent neglect, the sanctuary was swallowed by marshes.

It was recovered only in 1934 and in 1937 Paola Zancani Montuoro, in her Preliminary Report [2] on the results of excavation in the Sanctuary of Hera at river Sele mouth, wrote: "*… Objects are many, but still locked in cases and to be restored, they cannot be analytically described for the moment…*"

After countless vicissitude mainly due to war and waste of materials, not only from Paestum, occurred during those years, the cases were moved around until they get the storehouse of new Museum of Paestum, built in the Fifties.

Finally, a group of young archaeologists, first from the University of Salerno and then from the University of Naples Federico II, was assigned the exciting task to rearrange the remains and reopen those famous chests; the materials, still enveloped in newspapers from Thirties or Fifties, or stored in tin and cigarette boxes, especially provide records, lists, notes written during the excavations.

RESEARCH METHODOLOGY

The considered fragments belong to a quite wide chronological span following the sanctuary life period, especially from IV to III century b.C., just briefly mentioning the later production of medieval pottery.

The analyzed fragments have been chosen taken into account the already performed autoptic classification and obviously preferring those more remarkable within each class of materials, both from the typological and stylistic point of view. Such autoptic classification considered the technical characteristics of the pottery piece, especially colour and clay substance. The colour standard references are according to the MUNSELL *Soil Colour Chart* [3], widely used in pottery studies although not always universally accepted [4].

Special importance has been given to the most archaic pottery class, the Corinthian pottery, absolutely necessary in distinguishing the locally produced items from imported ones; while the analysis of medieval pottery fragments is mainly due to aim of demonstrating a continuity of use of the site, yet rather sporadic, and understanding the terms of use of such typical production techniques in this area.

The selected fragments of medieval glass pottery, both coming from excavations carried out within the V century b.C. Greater Temple area, are instead part of the well known specific issue of the glass leaded coating pottery, a very much developed sector of the archeometric analysis on ancient pottery finds. Recent studies and workshops [5] have particularly highlighted the remarkable role played by different coatings within the medieval pottery classifications. Therefore, establishing the characteristics of fragments from Heraion helps the archaeological research because could let state whether those hypothetical factories working in the Classic Age kept on performing a local production even during the Middle Age.

As regards metals, findings are not that many, but they are mostly coming from well determined stratigraphical contexts and testify the use of precious materials items for the holy ceremonies at the sanctuary spanning over a quite long period.

The excavations within the Temple area provided objects dating back to VI century b.C., among them fragments of an umbilicate *phiale* (S00/7722/202), a vessel used during certain holy ceremonies linked to libation rites; also fairly notable is the basin (S94/7110/682) found in excavation 7100, rich in votive materials and statuettes offered to the Goddess, and the ornamental element (S967411/17) coming from the spoliation trench filling of the Temple *peristasis* western side, elsewhere in the excavation providing some fragments of African sealed pottery as *terminus post quem*.

CORINTHIAN POTTERY

In the framework of studies on ancient production and extraction centres, the Corinthian pottery constitutes a noteworthy exception for quantity, precocity and specificity of intervention and laboratory tests performed. Really the Corinthian pottery has been always considered immediately recognizable under autoptic check for her bright colour [6], tender substance and smooth surface [7], so that sometimes a lacking description has been replaced by the note “Corinthian clay”. But actually such aesthetic homogeneity is only apparent: both colour and surface treatment can remarkably differ [8] and could not help at all in searching for the origin [9], as demonstrated by the instrumental tests carried out in Corinth mainly by the American School of Archaeology [10].

Choosing the Corinthian pottery samples the representativeness of typological and stylistic characteristics, in addition to the physical aspect and preservation state [11], has been taken into account, whilst the autoptic analysis carried out on handiworks constituted the basic work.

The analyzed finds fundamentally belong to four types – denoted as 3, 6, 7 and 8 – one of each divisible into two further subtypes, according to the more or less strong consistency or to the presence of much more inclusions (a, b): Here they follow:

Type 3

Highly pure pottery, with very small and rare black and white inclusions, quite tender and powdery. Referable to Munsell 2.5Y, only present in 8/2 hue and maybe inscribable within a Corinthian production likewise other published items with identical characteristics [12]. A scarce minority shows a larger amount of inclusions (subtype 3a)

Type 6

Highly pure pottery, with millimetric inclusions, mainly black and white, regular, quite tender and powdery, light brown colour M 7.5 YR, mainly present in 7/6 hue and more rarely in 7/4 hue. Probably both inscribable within a local production [13]. More uncertain, instead, the origin of 8/4 hue fragments, sometimes referred to a Corinthian production [14]. Those items showing a larger amount of inclusions can be included within subtype 4a.

Type 7

Fairly pure pottery, with millimetric black, white and micaceous inclusions, sometimes reddish, regular, quite tender and powdery. M 5 YR colour almost always in 7/6 hue, except very rare items showing 7/8 or 8/3 hue. This type can be referred with good certainty to a local production.

Type 8

Pure pottery, rare and millimetric black and white inclusions, homogeneous, slightly harder and less powdery than types 3 and 4. M 10 YR colour mainly showing a 8/3 hue, whilst 8/2 and 8/3 are less present. The most certified type in Poseidonia [15], but yet the one bearing more doubts.

Eleven fragments of Corinthian pottery underwent an experimental test, one for each autoptically identified group, according to the following scheme:

ID	NR. INV.	MATRIX	PIGMENT	NOTES	TYPE (on autoptic basis)
a3	S95/8001/3	-a		Probably Corinthian	6
a2	S96/7201/1	-a	p1= inner black; p2= outer black; p3= purple	Probably Corinthian	6
a7	S95/5906/47	-a	p1= black	Probably Corinthian	6
ab4	S94/7110/870	-a	p1= red	Local Kotyliskos	5
ab1	S97/7718/85	-a	p1= black	Local Kotyliskos	4a (more inclusions)
a6	S97/7718/87	-a	p1= red; p2= whitish	Probably local Pyx	5
a1	S95/7108/96	-a	p1= brown	Probably Corinthian small amphora	4a (more inclusions)
a4	S93/5404/14	-a		Black Corinthian kotyle	3
ab2	S97/7718/89	-a	p1= black	Fake kotyle	4
a5	S95/7110/688	-a	p1= black	Black Corinthian kotyle	6b (harder)
ab3	S94/7110/877	-a	p1= brown	Local Pyx	4

Table 1: scheme of the corinthian pottery

Excluding sample ab1, an *outsider* within the group, the concentration of Calcium, Titanium, Chromium, Manganese, Iron, Zinc, Rubidium, Strontium and Yttrium allow the identification of two groupings gathering materials showing similar spectra.

The obtained dendrogramma (cfr. fig. 1) allow a prompt check of the hypothesis advanced after the direct observation on materials: actually, it can be noticed that samples a2, a3, a4, a7 - representative of autoptic groups 3 and 6 within the first grouping – turn out extremely similar in components, and therefore much likely made of a clay coming from the same area. So far only descriptions can allow a connection between such evidences and a Corinthian production, but a comparison with the various rates of Corinthian clay chemical components, now impossible, would be desiderable [16]. Instead, misleading were the colour and composition of sample a6, within group 5: really in this case the somewhat orange clay together with the whitish engobe had let assume a local imitation. But the identical quantity [17] of chemical components presence let assume the same origin for this fragment too, whose colour could be simply due to a different extraction place [18]. In this outline, extremely interesting is the inclusion within the first grouping, therefore within the non local production, of the type 6 clay, quite doubtful and gathering the most evidences: actually such datum induces more caution in classifying the so-called imitation productions and a reflection about the effectiveness of an exclusively autoptic survey. Moreover, it becomes clear that the VI century b.C. import at *Heraion* go far beyond the local imitation productions.

The second grouping, called mixed because of his less homogeneity, only includes samples referring to types 4 and 5, reasonably enrolled within the local production [19]. In this case the instrumental tests totally confirmed the autoptic survey results, resolving the doubt of sample a1, showing an odd whitish colour combined to a typical local production composition, as well as of samples ab2 and a1, M 7.5 YR 8/4 colour, often referred to Corinthian production [20].

All the considered specimens show, when clear, a black, brown-black or brown or reddish clayey coating, always opaque [21], thin, barely covering, mostly flaking or ruined by encrusting or faint and readable only through his negative trace. The analysis of black, brown,

red and purple pigments, besides the whitish engobe sometimes evident, let state that this latter has been realized adding calcite, while black has been obtained from iron oxide, becoming a more or less dark and covering colour according to his different rate.

Obviously the advanced hypothesis will be verified only in the following researches: in this respect, a further analysis on clay samples collected from several city areas is needed, preferably using the same non destructive X-ray diffraction technique and even the X-ray diffraction technique unfortunately destructive where necessary, supported by cooking tests, whilst regarding pottery the microscopic analysis and neutron activation represent the only chance of direct comparison with the known Corinthian diagrams.

SCIENTIFIC ANALYSIS AVAILING OF ENERGY DISPERSIVE X RAY FLUORESCENCE PORTABLE SYSTEMS

The measurement of over 100 pieces were fulfilled availing of a mobile Energy Dispersive X Ray Fluorescence (EDXRF) instrument. EDXRF in a well known scientific method for the non destructive analysis of Cultural Heritage, mostly because it is non destructive, multielemental and relatively economic. The technique is based on the emission of X ray radiation as a consequence of X ray excitation. The photon emitted by the sample are characteristic of the chemical element analysed. The intensity of the X ray emitted is proportional to the concentration of the chemical element. To analyse the samples a portable system was used working with an X Ray tube tension of 35 kV and a tube current of 0.2 mA; the detector is a SDD (Silicon Drift Detector) with a resolution of 150 eV at 6.4 keV. The analysed areas on the samples have a diameter of 2 mm.

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Many of the metals analysed were heavily corroded, and are dated from the VI century b.C. to the III century b.C. This means that some of the fragments were produced at the beginning of the sanctuary life.

The fact that the pieces were corroded must be kept in mind when considering the quantitative results of the EDXRD measurements, as a matter of fact the analytical technique makes it possible to analyse only the surface of the sample. Most of the sample were indeed scrubbed to eliminate the influence of the corroded surface. Unfortunately the corrosion was very deep in some of the analysed samples, this could be the case of samples s914002-21 and s96-7212-54, a probe and a decorative element, with 17.6% of tin and 19.3 % of tin respectively. These values seem anomalous for archaic alloys productions. The first fragment derives from disturbed archaeological layers while the second derives from a precise dated layer, about the second half of the VI century b.C.

Very atypical is the lead and tin concentration in the sample s967411-17, a decorative element, with the 18.5% of lead and the 13.8% of tin dated about the III century b.C.

The sample s935007-48 shows a great concentration of iron, most probably this chemical enrichment is due to metallic incrustations deposited on the surface after the burial of the piece.

About the collection of metal samples, the pieces appear in general characterised by high levels of tin, around 11-13 % of tin. Some samples show although a lower concentration of tin, from 3% to 6 %. This low concentration is related to the functional nature of the objects, to the casting techniques used and last but not least to the aesthetic appearance of the objects (stud and phiale respectively).

The bronze alloy of most of the pieces show a concentration of lead from 1% to 5%. In this case, as for the tin, the presence of lead as to be connected with the nature and the usage of the pieces. It as to be notice that for many items the adding of lead was necessary to better the fluidity of the casting. The presence of lead ingots found in the excavation may suggest the idea that casting operations could have been performed in the area.

In two pieces s932704-16 and s935007-48 where silver was found in not low concentration, there is the possibility that it belongs to the rest of a silver coating for aesthetic reasons.

In table 2 we report the quantitative results on the bronze alloys.

DATING	NR. INV.	Cu (%)	Sn (%)	As (%)	Pb (%)	Fe (%)	Ag (%)	Zn (%)
VI – end V	s947110-682	87,2	12,7	0,0	0,0	0,0	0,0	0,0
after III	s967411-17	67,7	13,8	0,0	18,5	0,0	0,0	0,0
Second half – end VI	s977802-12	83,9	11,4	0,0	4,6	0,0	0,0	0,0
Disturbed layer	s914002-21	76,8	17,6	0,0	5,1	0,0	0,4	0,0
Disturbed layer	s932704-16	93,4	3,2	0,1	1,7	1,1	0,6	0,0
III cent.	s935007-48	78,7	11,2	0,1	5,7	3,2	1,0	0,0
VI cent.	s048305-35	82,9	13,0	0,1	1,7	1,6	0,0	0,8
Second half – end VI	s007722-202	92,3	6,6	0,0	0,0	1,2	0,0	0,0
Second half – end VI	s96-7212-54	79,6	19,3	0,0	1,1	0,0	0,0	0,0

Table 2: Quantitative results of bronze finds. Percentage value

Ingots of lead and copper have been found and analysed.

About the superficial colour layers on pottery we report some interesting cases.

The sample S94/5501/6, of medieval origin, was found to have a glazed surface. Two measurements were fulfilled, one on a green pigment and the second an engobe white. Lead is clearly distributed in both measurements. The green pigment is formed by a copper base pigment rather than ground pigments. The use of copper oxides (maybe cuprite) is typical and produces a very intense green colour.

The sample S00/7765/225+ 7738/209 on which a brown and a white colour layer have been analysed show the presence on the dark layer of a very high presence of manganese that can be connected with the use of pyrolusite or oxide of manganese. The presence of this oxide can give a gradation of dark colour that goes from violet to black.

About the last section of the research the main idea was to use the analysis of the matrix of the pottery to try to establish connections among pieces originated from the row materials used to fabricate them.

Different groups of homogeneous pottery were analysed and clusters were set.

In the next section part of the statistic multivariate analysis on Corinthian style pottery is reported.

The results of the different pieces were normalised in order to have a homogeneous set of data. The Compton response of the matrix was quantified and used as a normalisation factor. The chemical elements used for the statistical analysis were potassium, calcium, titanium, chrome, manganese, iron, zinc, rubidium, strontium and yttrium.

In the next picture we find the final result of the cluster analyses with Euclidean distance and Ward aggregation method of calculation. The results are discussed in a previous chapter "Corinthian Pottery".

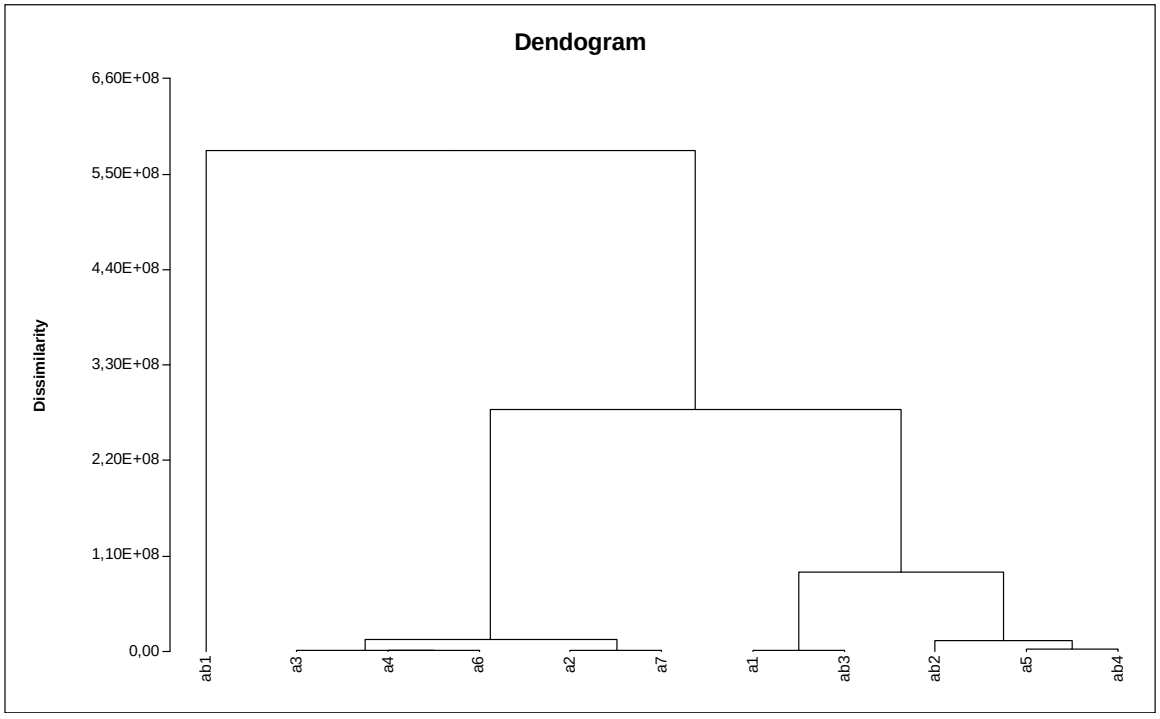

Figure 1: Dendrogramma of the Corinthian pottery samples

CONCLUSION

The aim of this paper was introducing the Sanctuary of Argive Hera and particularly the idea of combining two different professional figures as archaeologist and technologist; indeed, such integration can provide, through a scientific equipment used on the analysed materials, preferably in a not invading way, a remarkable contribute to the comprehension of archaeological finds.

In this case, the analysis carried out in the Sanctuary of Hera at river Sele mouth allowed the gathering of many very interesting information about the composition methods of individual items. Such information, supported by the scientific and technical data obtained from the excavation, let outline a clearer picture of the composition methods of these items and better define the importation methods of the most precious objects.

Therefore, the carried out study constitute a noteworthy starting point for further surveys allowing a better comprehension not only of the individual items composition but also regarding their local production or alternative import from other areas, within a wide complex

of cultural, political and historical dynamics involving the whole city of Paestum beyond the Sanctuary of Hera at river Sele mouth.

ENDNOTES

1. From the geological point of view, several field surveys, a stratigraphic study of 16 drillings, sedimentologic, micro-paleontologic, palynologic and mineralogic analysis have been carried out, obtaining a model of the Sele plain natural environment dating back to 79 A.D., a level sealed by a solid layer of pumice all over the area. In this respect, the already carried out survey on the so called "Argive Hera sequence" (Cfr. Senatore-Pescatore, cs.) will be studied more in depth, verifying which layer among those detected can be included within clays utilized for pottery production.
2. *Relazione Preliminare*, pp. 206-354.
3. The MUNSELL *Soil Colour Chart* is actually a reduced version, specific for soils, of the MUNSELL *Book of Colour*, in which 10 tables are present, with a range of colours from grey to red (R) to yellow-red (YR) to yellow (Y). The alphanumerci code shows the hue brightness first, then the reference colour, finally his saturation degree.
4. On doubts using the MUNSELL *Soil Colour Chart* cfr. Cuomo di Caprio 1982, p. 175.
5. Mannoni-Capelli 2002, pp. 57-60.
6. H. Payne directly links the colour brightness to the clay taken out in Corinth surroundings: "The fine pale clay […] is a distinctive feature of the landscape in the neighbourhood of Corinth" (PAYNE 1931, p. 181). The colour brightness is clearly due to his nature of primary clay.
7. Cfr. Amyx 1988, p. 536; Arafat- Morgan 1984, p. 330.
8. The colour is not always bright. Cfr. in particular the Corinthian plastic vases Amyx 1988, p. 514.
9. Two different productions - the first in hard clay and fine granulometry, light yellow, yellow-greyish or greenish, used for archaic statuettes matrices; the other generally more tender and darker, colour spanning from brown to brown-reddish, more often found in matrices from V and IV century b.C. (*Corinth* XV, 1 A, p. 82. *Corinth* XV, 2, p. 4) – are already noticed by A. N. Stillwell analysing pottery fragments found during 1931-1935 excavations at the craft quarter.
10. Studies aiming to specifically define the Corinthian pottery components started in the Sixties. A synthesis of researches is in FRANCO, *cs*.
11. All fragmentary samples have been chosen, in order to dispose for pottery analysis of the fracture thickness, absolutely unchanged and unhandled, representing the autoptically detected groups. Those fragments showing a better saved covering colour have been analyzed too. Cfr. Cuomo di Caprio 1982, p. 211.
12. Cfr. *Cuma II. Le fortificazioni*, pp. 167- 171, nn. 135, 136, 137, 138, 139, 140, 142, 145, 149, 150, 151, 152, 153, 156, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 177, 184, 187.
13. In fact, clay's characteristics and surfaces treatment share notable resemblances and similar colours with the classes: black varnish, ordinary clean pottery, Ionic cups and linear decoration pottery; and match quite well the production stated by Th. Menard as Paestan B.
14. Cfr. *Cuma II. Le fortificazioni*, pp. 168- 169, nn. 141, 144, 147, 148, 157. To identify this kind of clay as Corinthian cfr. Menard 1990, p. 84, note 4, and bibliography.
15. This type prevalence has been also noted at Santa Venera Sanctuary. Cfr. Menard 1990, p. 148, note 4.
16. A neutron activation expressed in percentage values and PPM has been used in order to detect the chemical components, while the X-ray diffraction has been used in analyzing

the clayey and non-clayey minerals. The obtained results cannot be compared to each other. Cfr. Farnsworth- Perlman- Asaro 1977, p. 457, table 1; Farnsworth 1970, p. 16, ill. I.

17. Except the Yttrium value, present in this item only.
18. Cfr. infra, note 10.
19. Cfr. infra, note 14.
20. Cfr. infra, note 15.
21. Likely because of the storing place, but also of the covering characteristics. Cfr. Amyx 1988, p. 537, pointing well out how the black varnish, for problems connected to diluition or cooking, could become brown, brown-reddish, orange-reddish or orange. Moreover, cfr. Farnsworth 1970, pp. 17- 19.

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