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Mobility of men versus mobility of goods: archaeometric characterization of Middle Bronze Age pottery in Malta and Sicily (15th-13th century BC)

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Abstract

The aim of this paper is to offer the first petrographic and chemical characterization of Middle Bronze Age pottery of Malta (Borġ in-Nadur, half of 15th - early 12th century BC) to discriminate, in the multitude of Borġ in-Nadur vessels found in coeval sites of south-eastern and central-western Sicily, between imports and imitations and to precisely define their provenance. The present research may provide new data in order to shed light on the long standing issue about 'mobility of men' and 'mobility of goods' between the two insular contexts. A significant amount of Borġ in-Nadur pottery from Malta and Sicily have been sampled and subjected to petrographic exam on thin sections; moreover, mineralogical and chemical analyses of major and trace elements were performed by X-ray diffraction and X-ray fluorescence spectrometry, respectively. Finally, chemical data were treated with statistical method (Aitchison, 1986) in order to attempt to distinguish Maltese and Sicilian Middle Bronze Age pottery productions.

Key words: Archaeometry; Middle Bronze Age; pottery provenance; Borġ in-Nadur.

Introduction

In the frame of the interconnections between Mediterranean prehistoric civilizations, the Sicily-Malta interaction has been a leitmotiv deriving from the geographic proximity of the two insular contexts and by a substantial cultural homogeneity over centuries. The evidences on which academics debate is represented by the occurrence of Maltese ceramics founds in Sicily and vice versa, apparently pointing to a 'mobility of goods' rather than a 'mobility of men' as main phenomenon of this interaction (Tanasi and Vella, 2014).

Being pottery the main indicator of exchanges, the inability of distinguishing between imports and local imitations, due to the absence of archaeometric characterizations, has misled scholars, preventing to have a correct perspective over this issue (Biehl and Rassamakin, 2008).

The archaeological implications of being not able to distinguish between those two classes of artifacts has left room in the studies of Sicilian and Italian prehistory to the proliferation of hypotheses about commercial and colonial routes especially with regard to relationship with the Aegean (Tanasi, 2005). Those hypotheses supported and shared for decades by the scholars have been recently put aside after the spread of the archaeometric analyses as new starting point in the approach of the material culture.

In this perspective, the most important case study is represented by the evidence of Middle Bronze Age Sicily, where a large amount of Maltese pottery has been found mainly in the south eastern coast (Tanasi, 2008). The Middle Bronze Age in Maltese archipelago is characterized by the Borġ in-Nadur culture, chronologically ranging between the half of 15th and the early 12th century BC and subdivided into three phases, Early, Middle and Late (Copat et al., 2012; Cazzella and Recchia, 2012; Tanasi, 2013). This Maltese facies is partially coeval with the development of the Thapsos one, that represents all the cultural production of Middle Bronze Age in Sicily.

The evidence of Borġ in-Nadur pottery in Thapsos contexts, often stressed as a critical phenomenon of cultural interweaving (Tanasi, 2010; 2011; 2013), has pointed to a hypothetical strong commercial relation between the islands in this period. The discovery of Thapsos pottery in few Maltese sites further supported this hypothesis (Tanasi, 2008) (Figure 1).

However, the recent literature has clarified how the simple macroscopic analysis of pottery and consequent fabric grouping can be systematically denied by the archaeometric exams, emphasizing a need of abandoning the traditional archaeological approach of visual observation in the study of pottery (Maniatis, 2009). In this perspective, proper archaeometric analyses appear necessary to clarify all interpretations on the Borġ in-Nadur- Thapsos frame.

Besides a preliminary research on technological issues of Maltese prehistoric pottery production attempted in the past (Molitor, 1992), the analysis carried out on a group of Late Neolithic, Early and Middle Bronze Age specimens sampled from the University of Malta excavations at Tas-Silġ remains the only study appeared in this field (Mommsen et al., 2006). Consequently, with regards to Borġ in-Nadur pottery, all attempts at classification, and subsequent chronological reconstructions, have been based on a visual examination (Trump, 1961; Sagona, 2011; Tanasi, 2011; Copat et al., 2012).

For the aforementioned, an interdisciplinary project, aimed to create a database of petrographic and chemical data of Borġ in-Nadur type pottery found in the south-eastern coast of Sicily and in the Maltese archipelago, have been launched by the University of Catania and Arcadia University in partnership with Heritage Malta and the Superintendence of Cultural Heritage of Malta.

Geological setting

The south-eastern section of Sicily is part of Hyblean Plateau Domain. From a geological point of view, it is composed by a carbonate platform succession date back from Triassic to Quaternary. In detail, the outcropping Formations are manly represented by Miocenic carbonate sequences usually divided in a eastern and western facies association, namely M.ti Climiti Fm. and Ragusa Fm., respectively (Finetti et al., 2005). Clay sediments are mainly

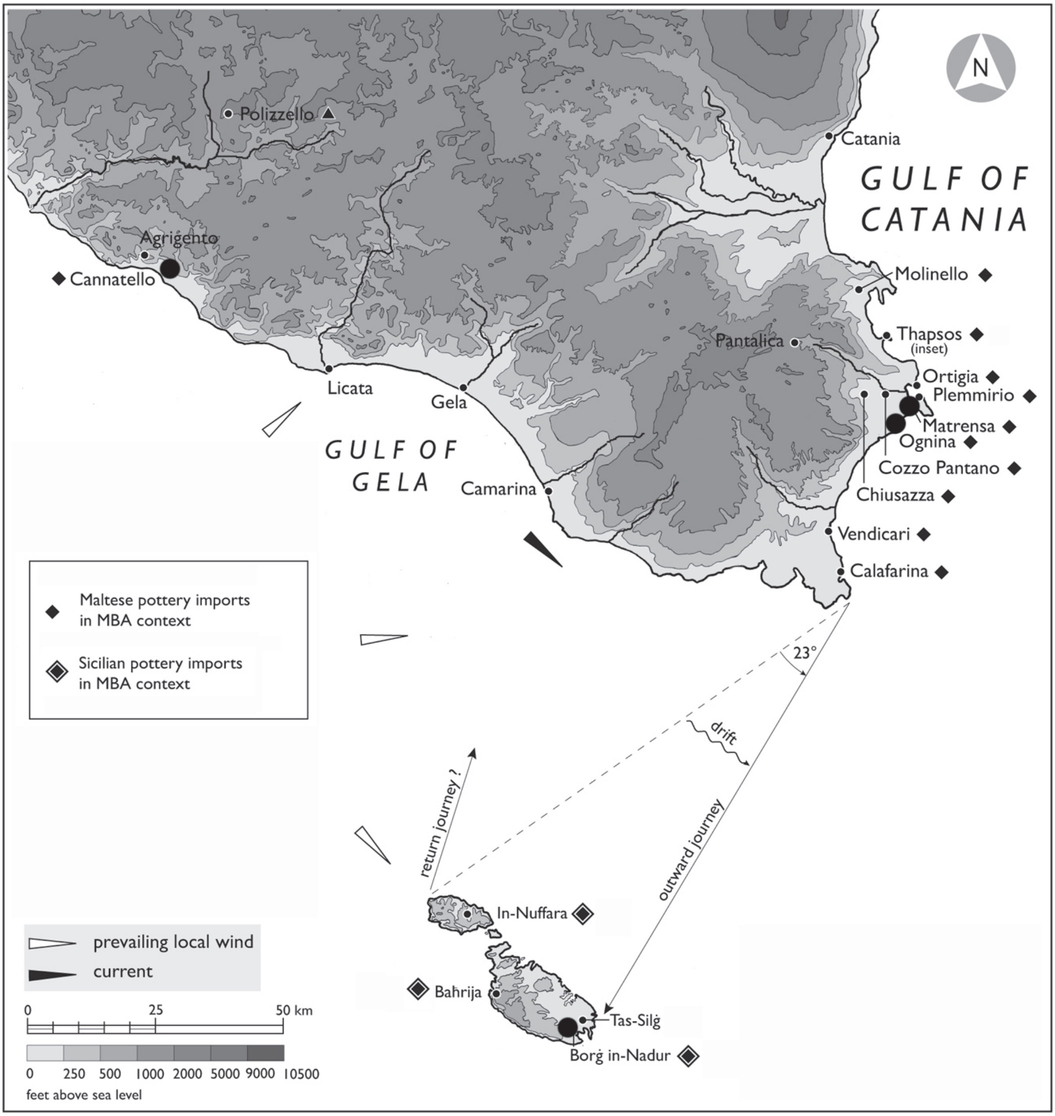

Figure 1. Map of southeastern Sicily and Malta with indications of sites involved in the ceramic interchanges.

represented by Plio-Pleistocene mudrocks and by quaternary alluvium.

A submerged extension of the this carbonate platform links the south-eastern area of Sicily and the Maltese archipelago. This latter one is characterized by outcropping Tertiary succession composed by Oligocene and Miocene carbonates, namely Lower Coralline Limestone Fm., Blue Clay Limestone Fm. and Upper Coralline Limestone (Pedley et al., 1976).

Experimental

Materials

Concerning Borġ in-Nadur pottery from Malta (Table 1, Figures 2-3), during a recent reappraisal of the ceramic assemblage produced by excavations of D.H. Trump at the settlement of Borġ in-Nadur (Trump, 1961; Tanasi, 2013), 28 samples have been taken. They represented all the identifiable wares and fabric types referable to the two main chronological sub-phases of the Borġ in-Nadur culture - Classic and Late - including, besides the 26 pottery pieces, one rough clay render and an anchor shaped clay object used for weaving threads. In addition, two samples of Blue Clays Formation collected from Ġnejna Bay in north-west Malta were studied for chemical comparative analyses.

Referring to Borġ in-Nadur pottery type found in Middle Bronze Age Sicilian archeological contexts, a selection of samples from two sites of the eastern side of Sicily, namely Ognina and Matrensa, and one of the western, Cannatello, have been studied (Table 1, Figure 4). About the sample IDs reported in Table 1, they have assigned in relation to the archeological site of provenance: BN/# stands for Borġ-in-Nadur (Malta), OG/# stands for Ognina (Sicilia),

Table 1. List of Maltese pottery samples from Borġ in-Nadur and Sicilian pottery samples with indication of shape type, provenance, chronological phase and analyses carried out.

Sample ID	Shape	Provenance	Chronological phase	Petrographic analysis	Mineralogical analysis (XRD)	Chemical analysis (XRF)
BN1	Cup	Trench G, Layer 2	Late Borġ in-Nadur	•		•
BN2	Rim of a tray	Trench I, Layer 5	Late Borġ in-Nadur	•		•
BN3	Rim	Trench G, Layer 2	Late Borġ in-Nadur	•		
BN4	Jar	Trench G, Layer 2	Late Borġ in-Nadur	•		•
BN5	Portion of foot	Trench G, Layer 2	Late Borġ in-Nadur	•		•
BN6	Cup	Trench G, Layer 2	Late Borġ in-Nadur	•		•
BN7	Body of cup	Trench I, Layer 5	Late Borġ in-Nadur	•	•	•
BN8	T shaped handle	Trench C, Layer 3	Late Borġ in-Nadur		•	•
BN9	Conical foot	Trench G, Layer 2	Late Borġ in-Nadur	•	•	•
BN10	Wall	Trench G, Layer 2	Late Borġ in-Nadur			•
BN11	Cup	Trench N, Layer 4-7	Classic Borġ in-Nadur	•		•
BN12	Rim	Trench G, Layer 2	Late Borġ in-Nadur		•	•
BN13	Dipper cup	Trench G, Layer 2	Late Borġ in-Nadur	•		•
BN14	Wall	Trench G, Layer 2	Late Borġ in-Nadur			•
BN15	Bell-shaped foot	Trench C, Layer 3	Late Borġ in-Nadur	•		•
BN16	Wall	Trench C, Layer 3	Late Borġ in-Nadur	•		•

Table 1. Continued …

Sample ID	Shape	Provenance	Chronological phase	Petrographic analysis	Mineralogical analysis (XRD)	Chemical analysis (XRF)
BN17	Cup	Trench G, Layer 2	Late Borġ in-Nadur		•	•
BN18	Tray	Trench C, Layer 3	Late Borġ in-Nadur	•		•
BN19	Cup	Trench N, Layer 4-7	Classic Borġ in-Nadur	•		
BN20	Tray	Trench C, Layer 3	Late Borġ in-Nadur	•		•
BN21	Rim	Trench G, Layer 2	Late Borġ in-Nadur		•	•
BN22	Rim	Trench H, Layer 2	Late Borġ in-Nadur	•		•
BN23	Rim	Trench H, Layer 2	Late Borġ in-Nadur	•		•
BN26	Cup	Trench H, Layer 2	Late Borġ in-Nadur	•		•
BN27	Rim	Trench H, Layer 2	Late Borġ in-Nadur	•		•
BN28	Cup	Trench H, Layer 2	Late Borġ in-Nadur	•		•
BN30	Clay anchor	Trench J, Layer 2	Late Borġ in-Nadur	•		
BN31	Clay render	Trench H, Layer 2	Late Borġ in-Nadur	•		•
BN33	Clay	Ġnejna Bay	Blue Clays Formation			•
BN34	Clay	Ġnejna Bay	Blue Clays Formation			•
OG12/6	Base	Ognina (Siracusa)	Thapsos	•		•
OG12/36	Pedestal	Ognina (Siracusa)	Castelluccio	•		
OG12/46	Bowl	Ognina (Siracusa)	Thermi Ware	•		•
OG12/51	Pedestal	Ognina (Siracusa)	Castelluccio	•	•	•
OG12/94	Wall	Ognina (Siracusa)	Thapsos	•		
OG12/128	Cup	Ognina (Siracusa)	Borġ in-Nadur type	•		•
OG12/131	Wall	Ognina (Siracusa)	Borġ in-Nadur type	•		•
OG12/140	Wall	Ognina (Siracusa)	Borġ in-Nadur type	•	•	•
OG12/151	Wall	Ognina (Siracusa)	Borġ in-Nadur type	•		•
OG12/154	Bowl	Ognina (Siracusa)	Thermi Ware	•	•	•
OG12/163	Handle	Ognina (Siracusa)	Thapsos	•		
18704	Cup	Matrensa (Siracusa)	Borġ in-Nadur type	•		•
18709	Cup	Matrensa (Siracusa)	Borġ in-Nadur type	•		•
CAN 71/94	Jar	Cannatello (Agrigento)	Borġ in-Nadur type	•	•	•
Sicilian clays (15 samples)	Clay	Siracusa and Agrigento	Plio-Pleistocenic clays			•

Figure 2. Middle Bronze Age ceramics from the settlement at Borġ in-Nadur sampled for archaeometric analyses with indication of the sample ID.

CAN/# stands for Cannatello (Sicilia) and 18/# stands for Matrensa (Sicily), while progressive numbers stand for inventory.

The site of Ognina (Siracusa) has been known in the scientific literature for the discovery of Maltese pottery in contexts of Early and Middle Bronze Age during the excavations carried out in ‘60s (Bernabò Brea, 1966): the so called Thermi Ware associated with local Castelluccio pottery and the Borġ in-Nadur ware in connection with local Thapsos pottery. During a field work carried out in summer 2012 by a team of the Arcadia University new pottery of Maltese type have been found at the islet of Ognina. In particular, the excavation produced examples of Thermi ware, a class believed to be locally

Figure 3. Middle Bronze Age ceramicsfrom the settlement at Borġ in-Nadur sampled for archaeometric analyses with indication of the sample ID.

made under the inspiration of an Early Bronze Age Maltese pottery style, and a certain amount of Middle Age pottery specimens. Among these materials, four samples of Maltese pottery of Borġ in-Nadur type (OG12/131, OG12/128, OG12/140, OG12/151), two samples of Thermi ware (OG12/154, OG12/46), three samples of Castelluccio (OG12/36, OG12/51) and three samples of Thapsos pottery (OG12/6, OG12/94, OG12/163) have been considered for archaeometric comparative analyses.

In terms of typology, the materials sampled from Ognina are all belonging to Early and Middle Bronze Age tableware. The Thermi ware samples are bowls with inverted lips, sometimes coming with flat bases or low conical pedestals;

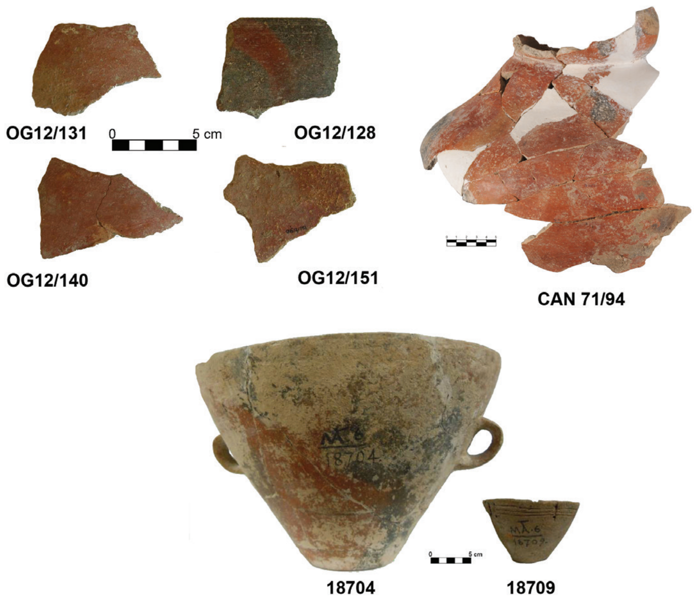

Figure 4. Middle Bronze Age ceramics from Ognina (OG12/131, OG12/128, OG12/140), Cannatello (CAN 71/94) and Matrensa (18704, 18709) sampled for archaeometric analyses.

the Borġ in-Nadur type specimens are conical cups, usually coming with embossed bases or high conical pedestals; the Castelluccio and Thapsos specimens are related to simple based or pedestal cups very common in the Sicilian Bronze Age pottery repertoire (Tanasi and Vella, 2014). The selection criterion is related to the typology of samples, all belonging to tableware type.

The necropolis of Matrensa (Siracusa) is considered one of the most relevant site for the study of Maltese presence in Sicily due to the high number of Borġ in-Nadur type vessels found in tomb 6 (Orsi, 1903). Two representative examples from that assemblage, cups 18704 and 18709, traditionally considered Borġ in-Nadur imports, have been sampled for analyses. The typology of those two cups is completely comparable with the other fragmentary samples recovered in the site. Being in this case 18704 and 18709 intact, it has been possible to clarify that they were not drinking vessels but small open containers for holding food in semi-liquid state.

In western Sicily, the only site where Maltese pottery have been reported is the fortified settlement of Cannatello (Agrigento) (Deorsola, 1996; De Miro, 1999; Levi, 2004). In a recent survey of the unpublished ceramics, a red slipped amphora, CAN71/94 (Tanasi, 2014) directly recalling the typology 1C of Borġ in-Nadur amphoras classification (Tanasi, 2011) has been identified and sampled. The vessel from Cannatello, in a very good state of preservation, represents an unique example of Maltese type transport jar, as in archeological sites of Malta this shape has been recovered only in fragmentary examples.

Finally, local clay sediments from south-central and west-central Sicily (Plio-Pleistocenic

Clays) have been sampled and analysed in order to identify a possible source of raw materials used in Middle Bronze Age Sicilian pottery production.

Methods

Petrographic descriptions on thin sections have been made following a simplified and modified scheme by Whitbread (Whitbread, 1995), which facilitates a detailed characterization of pottery in terms of texture, groundmass and inclusions. Mineralogical data have been collected by using a Siemens D5000 diffractometer (Cu Ka radiation, 40 kV, 30 mW and Ni filter). Chemical analyses of major and trace elements were performed by X-ray fluorescence (XRF) spectrometry (PHILIPS PW 2404/00) on powder-pressed pellets; total loss on ignition (LOI) was gravimetrically estimated after overnight heating at 950 °C. The details about XRF method are reported in (Barone et al., 2013). Chemical data have been finally treated by using a statistical approach mainly based on the log-ratio technique introduced by Aitchison (Aitchison, 1986) and employed in order to avoid the constant sum problem.

In detail, the centered log-ratio transformation (clr) of data is applied as follows:

$x \in SD \rightarrow y = \log (xD / gD (x)) \in RD$

where x = composition, xD = (x1, x2, ….xD), y = log transformed composition and $gD(x) = D\sqrt{(x1 \cdot x2 \cdots\cdots\cdot xD)}$. This operation transforms the data from their constrained sample space, the simplex Sd, into the real space Rd where parametric statistical methods can be applied to the transformed data. Next, the clr-transformed dataset is explored by biplots, a graphical representation of variables and cases projected onto principal components planes (PCA). Both clr-transformation and biplots calculation have been obtained by using CoDaPack (Thiò-Henestrosa, 2005), a compositional software that implements the basic methods of analysis of compositional data based on log-ratios, following the methodology introduced by Aitchison.

Results

Petrographic observations

With regards to petrographic analyses performed on the studied samples from Malta and Sicily, the pottery were grouped considering the petrographic characteristics of the groundmass and inclusions. Microphotographs of representative samples are shown in Figure 5.

In details, the following five different fabric have been identified:

- Fabric Ch^{MC}: medium coarse potteries (specimens OG12/128, OG12/140 (Figure 5a), OG12/131, OG12/151, CAN 71/94 (Figure 5b), BN1, BN3, BN5, BN6, BN7 (Figure 5c), BN11, BN13, BN16, BN18, BN19, BN26, BN28) characterized by dominant grog and carbonatic microfossil-rich groundmass. Referring to microstructure, samples show open spaced distributed channels and planar voids with remains of carbonaceous material (especially in samples labeled as BN), vughy and vescicles, the latter ones slightly preferential oriented. The groundmass is heterogeneous and characterized by brownish-greyish color and high/medium high optical activity in samples labelled as BN/# and medium optical activity in OG/# and CAN/# ones.The inclusions are characterized by unimodal/bimodal grain size distribution and are mainly represented by coarse grog with prevalently sub-angular shape and millimetric dimensions and by common fine quartz. Finally, brownish-black amorphous phases are present, measuring about 0.5 mm in diameter.
- Fabric CC^{MC}: medium-coarse potteries (specimens BN2, BN4, BN9, BN15,

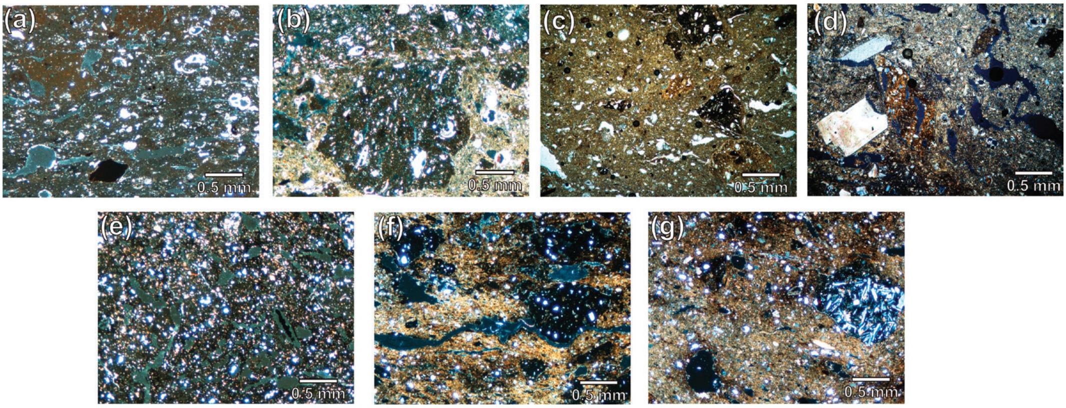

Figure 5. Thin sections of the specimens belonging to the five fabrics identified. Fabric Ch^{MC}: (a) OG12/140, (b) CAN71/94, (c) BN7; Fabric CC^{MC}: (d) BN23; Fabric ChQ^{F}: (e) 18704; Fabric ChF^{MC}: OG12/154 (f) ; Fabric ChV^{MC}: OG12/6 (g).

BN20, BN22, BN23(Figure 5d), BN27, BN30, BN31), characterized by spatic calcite. The voids microstructure is similar to that observed in the previous fabric; noteworthy is the presence of carbonaceous materials inside planar voids and the absence of preferential orientation. The groundmass rich in microfossil is very heterogeneous with high optical activity and yellowish-greyish color. The grain size distribution of inclusions is polymodal with grog and spatic calcite in the coarse fractions and quartz in the finer one. Volcanic rock fragment inclusions characterized by microcrystalline and intergranular texture with plagioclase, oxides, pyroxenes in matrix and phenocrysts of olivine and plagioclase are present just in sample BN27.The grog is sub-angular in shape with millimetric dimensions and it has the same paste of samples in which occurs. Finally, mainly reddish amorphous phases are also present in samples of this fabric.

- Fabric ChQ^{F}: fine pottery (specimen 18704 (Figure 5e) with grog and micaceous groundmass. In this sample, the vughy microstructure is characterized by channel, vughy and vescicles without preferential orientation. The mica-rich groundmass is quite homogeneous, with medium-low micromass optical activity and brownish-yellowcolour. The inclusions are mainly represented by grog in the coarse fraction and quartz in the fine one, with a bimodal grain size distribution. Reddish-black amorphous phases are also present.
- Fabric ChF^{MC}: medium-coarse potteries (specimens 18709, OG12/46 (Figure 5f), OG12/154, OG12/94) with grogand microfossil-rich groundmass. In detail, the vughy microstructure, it is characterized by not preferential oriented and single spaced channels, vughy and vescicles. The microfossil-rich groundmass is heterogeneous and show a medium micromass optical activity and a brownish-yellow colour. The inclusions are mainly represented by grogand fine quartz, with a bimodal grain size distribution. Finally, reddish-black amorphous phases are present.

- Fabric ChV^{MC}: medium-coarse potteries (specimens OG12/6 (Figure 5g), OG12/36, OG12/51, OG12/163.) characterized by volcanic rock fragments inclusions and micaceous groundmass. Samples show a double spaced void microstructure characterized by vughy, channel and vescicles without preferential orientation. The groundmass is quite heterogeneous and characterized by a medium-low micromass optical activity and brownish-yellow colour. The inclusions show a polimodal distribution and are mainly represented by grog and volcanic rocks fragments in the coarse grain fraction and quartz and plagioclase in the fine one. The volcanic fragments are characterized by microcystalline, intergranular texture with plagioclase, oxides and pyroxene in matrix and phenocrysts of olivine and plagioclase. Reddish-black amorphous phase are also present.

Mineralogical analysis

X-ray diffraction measurements have been carried out on a selection of representative samples of petrographic Fabrics and provenance aiming at obtain mineralogical composition and esteem firing temperature. The latter ones can be preliminary esteemed by using information about micromass optical activity; usually, low birefringence is related to modification of the original composition and texture of ceramics due to reactions among minerals in the clays during firing process (calcite and clay minerals). In particular, Ca-rich cryptocrystalline silicates (i.e., gehlenite, anorthite, diopside and/or wollastonite) can growth and their presence is indicative of medium-high temperature achieved.

As aforementioned, in Table 2 petrographic data about birefringence and semi-quantitative mineralogical composition of the studied samples are reported.

Referring to samples belonging to Fabrics Ch^{MC} and CC^{MC} the obtained data highlight the

Table 2. Petrographical and mineralogical data of studied samples.

ID Sample	Fabric	Bir.	Qz	Cc	Di	An	Geh	Hm	CM
BN7	Fabric ChMC	H	+++	++	-	-	-	-	++
CAN 71/94	Fabric ChMC	M-H	+++	++	-	tr	-	tr	++
OG12/140	Fabric ChMC	M-H	+++	++	-	+	tr	-	++
BN9	Fabric CCMC	H	+++	++	-	-	-	-	++
OG12/154	Fabric ChFMC	M	+++	+	-	+	-	tr	++
OG12/51	Fabric ChVMC	M-L	+++	+	+	tr	-	-	+
BN8	Unknown	-	++	tr	+	++	tr	-	+++
BN12	Unknown	-	+++	++	-	+	tr	-	++
BN17	Unknown	-	++	+	-	+	tr	-	++
BN21	Unknown	-	++	++	-	-	-	-	++

Bir. = Birefringence: H = high, M = medium, L = low. Qz = quartz; Cc = calcite; Di = diopside; An = anorthite; Geh = gehlenite; Hm = hematite; CM = clay minerals.
(+) is related to the relative phase abundance; tr = trace.

presence of calcite and clay minerals, suggesting low firing temperature (< 800 °C), in accordance to birefringence data; however, in samples from Ognina and Cannatello, exhibiting medium-high groundmass optical activity, also trace of gehlenite and anorthite have been identified, claiming higher firing temperature (~ 800 °C).

Newly formed Ca-silicates (i.e., gehlenite and anorthite) are revealed also in sample of Fabric ChF^{MC}, suggesting medium-high temperature (~ 800-850 °C). Note worthy is that for samples exhibiting volcanic inclusions (Fabric ChV^{MC}) nor anorthite neither diopside can be used in esteeming firing temperature, as related to composition of tempers. Finally, referring to samples with unknown fabric the presence of calcite and clay minerals in association with trace of gehlenite and anorthite, suggests the achievement of medium-low firing temperature (~ 800 °C); however the unavailability of petrographic information don't allow to exclude the presence of recrystallized calcite.

On the whole, on the basis of mineralogical data and petrographic observation, the presence of both Ca-silicates and calcite in all samples suggests the achievement of medium-low firing temperatures (≤ 800 °C).

Chemical analysis

In order to characterize Maltese pottery production and distinguish on chemical basis Sicilian and Maltese ceramics, chemical data obtained by XRF measurements (Table 3) were processed by a well-known statistical method, previously successfully applied on pottery (Aitchison et al., 2002; Buxedai Garrigòs, 1999; Barone et al., 2005; Barone et al., 2012).

Moreover, obtained results on pottery specimens have been compared with Maltese (BN 33 and BN 34 samples) and Sicilian clays (Plio-Pleistocenic clays) in order to verify the possible identification of raw materials used in production processes.

Referring to major and minor elements, the binary diagrams SiO_2 vs. Al_2O_3 and Rb vs. Zr show a principal field related to BN# samples and Maltese clays and a separate field related to Sicilian potteries and clays (Figure 6). In this framework, it is noteworthy that OG# and CAN# samples are plotted with the Borg-in-Nadur Maltese pottery trend.

In order to highlight the compositional differences between materials coming from Sicily and Malta, chemical data have been treated thought principal component analysis (PCA). The biplot of Figure 7a represents all studied samples (both potteries and clays) plotted in the first two principal component plan. It is worth noting that there is a very good correspondence among the petrographic observations and the groups recognizable in the biplot. In particular, it is possible to distinguish two different areas referred to Maltese and Sicilian materials. Also in this case, Borġ in-Nadurtype potteries from Cannatello (CAN 71/94) and Ognina (OG12/128, OG12/140, OG12/131, OG12/151) are plotted in the same area of Borġ in-Nadur samples (BN#) and of clays from Malta, according to a petrographic observation and binary diagram.

On the contrary, samples referred to Sicilian Middle Bronze Age cultures (OG12/6, OG12/51 - Fabric ChV^{MC}) and Thermi Ware type pottery (OG12/46, OG12/154 - Fabric ChF^{MC}) are plotted in the same area of Sicilian Plio-Pleistocenic clays. In the end, about specimens from Matrensa, some doubts still arise about their provenance, even if sample 18704 shows to match with Maltese materials, while the sample 18079 is isolated respect to the two identified groups.

The variables having the highest variance were taken for setting up the discriminating triangular diagram Zr-Rb-La of Figure 7b, in which it is more evident both the discrimination between Maltese and Sicilian pottery and raw materials evidenced in the previous diagram.

Finally, in order to prove the differences

Table 3. Chemical composition of the analysed samples. Major element are reported in wt%, minor elements in ppm.

Sample ID	Provenance	Fabric	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
BN1	Malta	ChMC	53.94	1.03	15.91	5.41	0.03	2.45	17.17	0.54	3.11	0.42	0.00
BN5	Malta	ChMC	46.32	0.76	13.64	4.19	0.03	2.24	16.17	0.53	2.18	0.24	13.70
BN6	Malta	ChMC	56.12	0.87	14.39	4.55	0.03	2.48	13.38	1.24	3.28	0.22	3.45
BN7	Malta	ChMC	36.33	0.63	11.40	3.45	0.02	2.02	21.09	0.30	1.63	0.24	22.91
BN11	Malta	ChMC	44.15	0.70	12.82	3.42	0.02	1.91	20.86	0.70	3.02	0.25	12.15
BN13	Malta	ChMC	44.31	0.77	13.39	4.06	0.03	2.20	20.78	0.66	2.58	0.42	10.81
BN16	Malta	ChMC	47.65	0.79	13.99	4.43	0.03	2.26	16.03	0.68	2.48	0.33	11.34
BN18	Malta	ChMC	45.50	0.79	14.11	4.43	0.03	2.09	16.44	0.61	2.50	0.29	13.21
BN26	Malta	ChMC	44.42	0.72	13.06	3.88	0.02	1.78	18.21	0.59	2.09	0.24	15.00
BN28	Malta	ChMC	54.70	1.14	17.06	6.82	0.02	2.03	8.93	0.59	2.74	0.25	5.72
CAN71	Cannatello - Sicily	ChMC	45.68	0.82	14.19	4.35	0.03	1.86	19.59	0.32	2.89	0.32	9.95
OG12/128	Ognina (SR) - Sicily	ChMC	52.12	0.89	15.66	5.55	0.04	2.33	15.20	0.55	2.62	0.37	4.67
OG12/131	Ognina (SR) - Sicily	ChMC	54.33	0.99	15.67	6.06	0.04	2.64	11.16	0.90	3.17	0.25	4.79
OG12/140	Ognina (SR) - Sicily	ChMC	53.86	1.02	15.74	6.45	0.04	2.45	11.22	0.81	3.09	0.27	5.05
OG12/151	Ognina (SR) - Sicily	ChMC	38.08	0.54	11.13	3.15	0.04	1.64	24.33	1.22	2.24	0.57	17.06
BN2	Malta	CCMC	30.39	0.45	9.21	2.31	0.01	1.82	27.27	0.82	1.75	0.33	25.63
BN4	Malta	CCMC	35.05	0.50	10.42	2.68	0.01	2.17	23.03	0.61	1.40	0.36	23.79
BN9	Malta	CCMC	47.33	0.71	12.50	4.03	0.03	2.02	18.51	0.92	2.24	0.31	11.40
BN15	Malta	CCMC	46.89	0.62	12.09	3.52	0.02	2.10	14.81	1.16	2.05	0.25	16.49
BN20	Malta	CCMC	47.35	0.92	14.68	4.45	0.09	2.16	21.93	1.02	4.42	1.69	1.29

Table 3. Continued…

Sample ID	Provenance	Fabric	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
BN22	Malta	CCMC	40.22	0.66	12.45	3.89	0.02	2.17	19.19	0.48	1.80	0.18	18.93
BN23	Malta	CCMC	35.29	0.59	11.23	2.98	0.03	2.03	22.98	0.36	1.65	0.30	22.57
BN8	Malta	Unknown	50.72	0.86	15.41	5.08	0.03	2.33	17.34	1.17	2.12	0.31	4.64
BN10	Malta	Unknown	44.73	0.70	12.56	3.71	0.02	1.89	16.31	0.42	2.12	0.25	17.30
BN12	Malta	Unknown	47.60	0.85	14.45	4.58	0.03	2.24	17.85	0.72	2.80	0.46	8.42
BN14	Malta	Unknown	49.24	0.87	15.30	4.77	0.03	2.08	15.26	0.67	2.80	0.52	8.46
BN17	Malta	Unknown	49.78	0.91	15.25	4.88	0.03	2.20	16.98	0.43	2.93	0.32	6.30
BN21	Malta	Unknown	49.98	1.01	15.55	5.81	0.03	1.94	10.01	0.69	2.61	0.37	12.01
BN27	Malta	Unknown	45.58	0.80	13.62	4.81	0.03	2.54	13.14	0.68	2.26	0.27	16.28
BN31	Malta	Unknown	15.75	0.24	4.72	0.92	0.00	1.79	41.14	0.49	0.82	0.53	33.60
18704	Matrensa - Sicily	ChF	56.72	0.87	13.66	4.67	0.05	1.82	9.75	0.84	2.65	0.19	8.77
18709	Matrensa - Sicily	ChFMC	49.66	0.64	12.83	3.22	0.02	1.15	9.35	1.50	0.37	0.12	21.14
OG12/6	Ognina - Sicily	ChFMC	55.36	0.90	12.53	4.90	0.06	2.28	8.71	1.66	2.05	0.16	11.40
OG12/46	Ognina - Sicily	ChFMC	54.76	0.89	12.94	5.62	0.07	2.25	9.78	1.98	2.00	0.22	9.51
OG12/51	Ognina - Sicily	ChVMC	56.00	0.94	14.83	6.20	0.07	2.14	9.57	1.26	2.47	0.26	6.27
OG12/154	Ognina - Sicily	ChVMC	54.27	0.87	13.82	6.01	0.05	2.06	8.31	1.62	2.38	0.34	10.27
Maltese Clays	Malta	Average value (2 samples)	25.48	0.38	8.22	1.92	0.01	2.33	28.83	0.50	1.43	0.26	30.66
Plio-Pleistocene Clays	Sicily	Average value (15 samples)	45.34	0.58	11.44	4.03	0.04	2.13	14.62	0.99	1.66	0.14	19.02

Table 3. Continued…

Sample ID	Provenance	Fabric	Sr	V	Cr	Co	Ni	Zn	Rb	Y	Zr	Nb	Ba	La	Ce	Pb	Th
BN1	Malta	ChMC	343	131	140	4	61	101	87	18	115	7	227	47	96	13	12
BN5	Malta	ChMC	338	109	119	4	45	76	49	11	75	2	246	34	71	9	13
BN6	Malta	ChMC	106	77	74	4	48	46	25	4	32	n.d.	145	32	29	5	n.d.
BN7	Malta	ChMC	492	94	102	5	48	87	63	19	121	10	369	31	56	15	7
BN11	Malta	ChMC	314	90	87	0	42	67	48	9	69	n.d.	217	31	61	9	13
BN13	Malta	ChMC	442	112	113	3	52	85	67	14	101	6	204	39	94	10	5
BN16	Malta	ChMC	330	107	110	6	46	81	56	12	80	2	262	37	81	12	11
BN18	Malta	ChMC	376	124	122	6	49	88	64	15	103	6	240	47	85	13	7
BN26	Malta	ChMC	331	81	95	2	47	65	41	8	63	n.d.	292	34	72	10	8
BN28	Malta	ChMC	120	143	136	6	74	104	68	17	96	2	241	47	79	12	15
CAN71	Cannatello - Sicily	ChMC	455	128	127	10	54	96	91	24	142	13	1196	52	85	17	11
OG12/128	Ognina (SR) - Sicily	ChMC	459	129	134	13	54	101	89	26	144	15	209	43	97	12	12
OG12/131	Ognina (SR) - Sicily	ChMC	230	91	94	8	56	74	47	12	67	n.d.	198	35	66	2	5
OG12/140	Ognina (SR) - Sicily	ChMC	272	99	104	7	57	75	55	16	80	2	201	41	84	14	10
OG12/151	Ognina (SR) - Sicily	ChMC	918	80	77	9	50	86	51	17	89	9	396	33	75	12	8
BN2	Malta	CCMC	327	69	74	4	58	69	32	10	45	n.d.	227	31	46	5	10
BN4	Malta	CCMC	253	54	71	2	49	55	27	8	36	n.d.	229	35	52	3	6
BN9	Malta	CCMC	266	86	92	1	43	65	31	8	51	n.d.	225	31	71	8	9
BN15	Malta	CCMC	150	56	54	0	34	43	15	3	23	n.d.	159	18	43	3	5
BN20	Malta	CCMC	470	112	118	12	64	161	93	52	275	27	363	59	113	18	16

Table 3. Continued…

Sample ID	Provenance	Fabric	Sr	V	Cr	Co	Ni	Zn	Rb	Y	Zr	Nb	Ba	La	Ce	Pb	Th
BN22	Malta	CCMC	489	112	115	7	46	81	72	21	124	12	318	41	85	15	8
BN23	Malta	CCMC	496	81	97	9	50	78	54	15	103	7	290	39	74	10	6
BN8	Malta	Unknown	256	110	111	5	50	71	37	10	71	n.d.	203	40	63	4	16
BN10	Malta	Unknown	235	83	95	5	42	65	34	7	53	n.d.	307	28	64	8	8
BN12	Malta	Unknown	446	135	130	8	53	94	80	16	113	8	197	49	91	14	9
BN14	Malta	Unknown	372	127	130	11	49	96	74	15	98	6	267	45	101	13	8
BN17	Malta	Unknown	392	143	130	9	54	97	87	17	115	9	183	46	97	15	8
BN21	Malta	Unknown	243	122	143	11	72	110	85	21	137	8	312	52	96	15	15
BN27	Malta	Unknown	306	110	125	9	57	85	64	14	95	6	204	37	73	11	3
BN31	Malta	Unknown	455	25	43	0	52	74	4	12	32	n.d.	96	15	45	3	9
18704	Matrensa - Sicily	ChF	148	81	59	-1	25	53	28	6	52	15	258	31	43	7	5
18709	Matrensa - Sicily	ChFMC	18	17	24	-2	14	20	3	0	8	18	123	8	17	4	n.d.
OG12/6	Ognina - Sicily	ChFMC	134	65	55	4	39	42	12	8	49	n.d.	269	19	40	n.d.	2
OG12/46	Ognina - Sicily	ChFMC	170	92	68	7	44	59	27	13	80	n.d.	273	32	51	1	4
OG12/51	Ognina - Sicily	ChVMC	336	127	114	11	45	94	91	24	194	19	287	44	100	14	9
OG12/154	Ognina - Sicily	ChVMC	245	113	98	9	45	93	56	30	158	8	315	39	76	12	9
Maltese Clays	Malta	Average value (2 samples)	735	73	72	5	37	69	56	16	94	9	92	33	42	8	6
Plio-Pleistocene Clays	Sicily	Average value (15 samples)	427	101	80	7	33	65	74	24	195	14	203	30	69	13	9

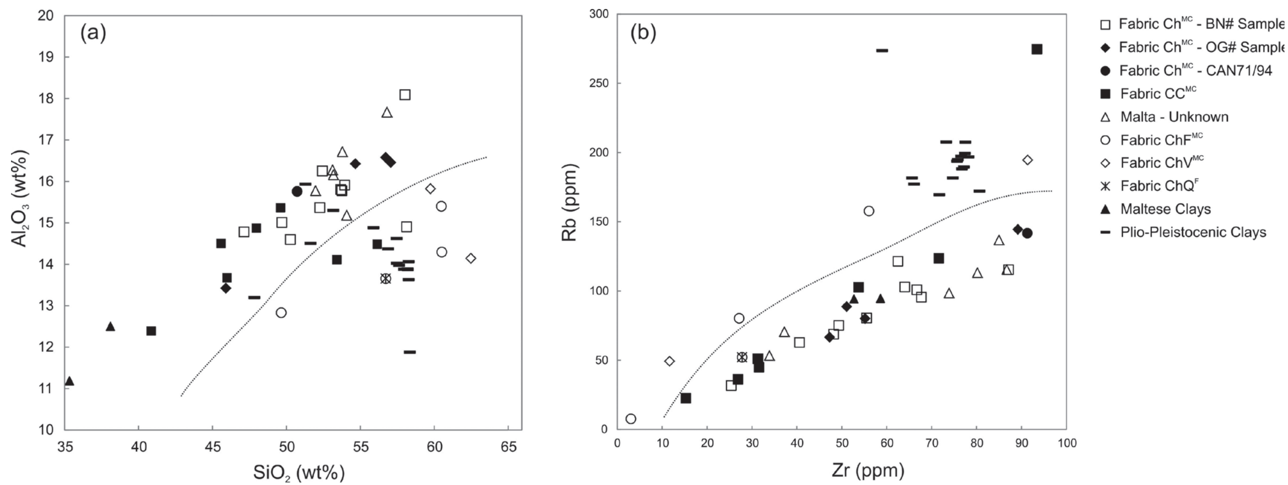

Figure 6. Binary diagrams of major and minor elements. (a) SiO_2 vs. Al_2O_3 and (b) Rb vs. Zr binary diagrams.

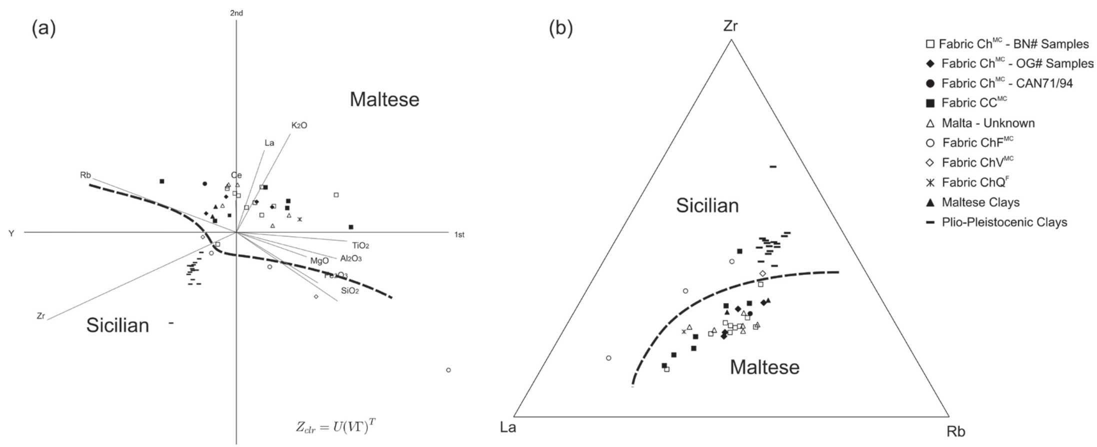

Figure 7. (a) Biplot of principal components; (b) Triangular diagram Zr-Rb-La.

in the chemical composition of Maltese and Sicilian samples, a multivariate discriminant analysis (Huberty, 1994) has been performed on data of trace elements. As shown in Figure 8, all the samples studied are correctly classified by the first discriminant function in which the elements with higher load are Zr and Cr with standardized canonical coefficient of -3.97 and 3.08 respectively.

Discussion

Petrographic, mineralogical and chemical analyses carried out for the first time on specimens sampled from the site of Borġ in-Nadur in Malta have allowed to obtain the first archaeometric characterization of Middle Bronze Age Maltese pottery production.

All the pottery classes sampled in Borġ in-Nadur site and identified by the scholars and known in literature can now be divided in the two groups, Fabric Ch^{MC} and CC^{MC}. This distinction corresponds to the binomial fine ware/coarse ware, where the fine ware is generally tableware, invariably slipped and decorated, and the coarse ware is represented by domestic or cooking forms.

The identity of Ognina (OG12/128, OG12/140, OG12/131, OG12/151) and Cannatello (CAN 71/94) samples with Maltese products, as claimed by petrographic (Fabric Ch^{MC}) and chemical features, is the first certain evidence of Borġ in-Nadur pottery imports in Middle Bronze Age Sicily. In detail, the four samples from Ognina, mainly represented by cups or small open vessels characterized by red slip decoration typical of Borġ in-Nadur type fine ware, suggest the introduction of

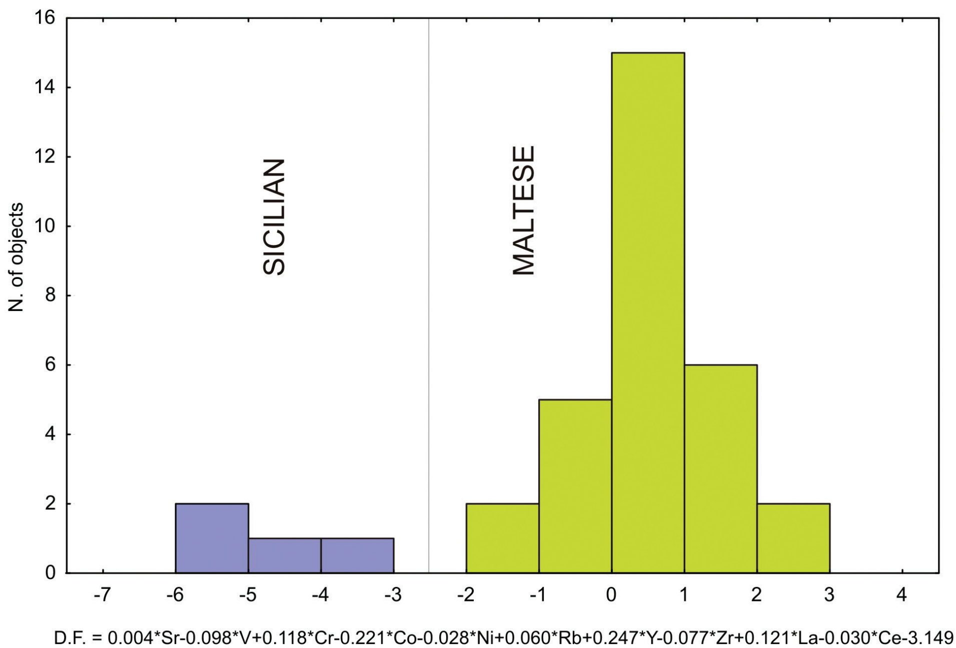

Figure 8. Discriminant analysis result expressed as histogram of the values of discriminant function (D.F.) for each samples. The diagram shows the bimodal distribution due to the individuation of two groups (i.e. Maltese and Sicilian pottery).

these vessels in Sicily ‘per se’ and not ‘for their content’. This element indicate a certain appreciation of the Borġ in-Nadur pottery type among the native community of Ognina.

On the other side, the Maltese provenance of the vessel from Cannatello, a large storage jar red slipped, informs us, for the first time, about the ‘mobility of goods’ from Malta to Sicily, a phenomenon never hypothesized before.

About the red slipped cup from Matrensa 18704, petrographic data allow to identify a fabric similar to the Borġ in-Nadur type pottery even if more fine in grain size (Fabric ChQ^{F}), as suggested by the typical decoration; chemical data confirm this features as the sample is grouped in Maltese materials area.

Among the certain Sicilian pottery production (Thapsos - OG/6, OG/94, OG/163 - and Castelluccio - OG/36, OG/51 - ware) and raw materials (Plio-Pleistocenic clays), noteworthy is the identification of the other Borġ in-Nadur type cup 18709 from Matrensa as a Sicilian product; both petrographic and chemical data suggest that this sample represent a product made in Sicily imitating Borġ in-Nadur prototypes. Local imitation routine is also suggested by the evidences of Thermi Ware type from Ognina (OG/46 and OG/154) that are characterized by petrographic and chemical features quite different from Maltese production.

Finally, information about firing temperature, obtained combining data about micromass optical activity and mineralogical composition, supply data about technological level of the two pottery production. In particular, the medium-high birefringence and the trace presence of Ca-silicates in samples of fabrics Ch^{MC} and CC^{MC} suggest medium-low firing temperature for these materials, maybe a clue of a mediocre technological level of Maltese Borġ in-Nadur production. However, the presence of new formed Ca-silicates in some samples from Borġ in-Nadur site and the variation in the petrographic features among pottery in term of inclusions, like spatic calcite as fire-resistant temper (Fabbri et al., 1997), may be attributed to a good specialization in manufacturing processes.

Conclusions

Results of this first in-depth archaeometric study of Borġ in-Nadur pottery type from Malta and Sicily have several remarkable archaeological implications.

The petrographic and chemical observations brought to the definition of a homogeneous reference Maltese local group, representing an important benchmark in the study of archaeometric provenance of Maltese Middle Bronze Age pottery and the distinction of Maltese and Sicilian Middle Bronze Age pottery productions.

In particular, the identification of well-defined fabrics for Maltese materials represents a distinctive feature of Borġ in-Nadur type pottery, allowing also to identify Maltese production among Middle Bronze Age ware found in Sicily. This consideration is confirmed by a geochemical approach based on the comparisons between pottery and local raw materials suggesting the possibility to use this procedure as a routine in the discrimination between the two pottery production. However, it is noteworthy that even if the Blue Clays sampled in Ġnejna Bay exhibit a chemical composition similar to Borġ in-Nadur samples, they cannot be certainly considered the raw materials used in the manufacturing of this production, considering the really high Ca levels shown. Therefore, further investigation has to be carried out about.

An important result seems to be the first discovery of Sicilian imitation of Maltese pottery, as suggested by local provenance for Thermi Ware type samples OG12/46 and OG12/154 from Ognina and Borġ in-Nadur type sample 18709 from Matrensa. The issue of imitation questions the theory of the exclusive commercial connections between Sicily and Malta and of the interpretation of all Borġ in-Nadur vessels found in Sicily as imports. Moreover, this suggests the presence of foreign potters in Sicily or an exchange of know-how between Maltese and Sicilian potters. In both cases, it presupposes a 'mobility of man' and the presence of foreign professionals in Sicily and not just of the products of their work. An escalating process of local imitations of Borġ in-Nadur pottery, that could be sustained by further analyses, can be interpreted either with a certain appreciation of Borġ in-Nadur ceramics among Sicilian natives either with a need of producing the Borġ in-Nadur ware for being used by eventual Maltese immigrants still anchored to their traditional behaviors. The superior firing temperature of local Sicilian pottery in comparison with the coeval Maltese suggests that the appreciation was not probably based on the technical level of that production but likely on its appeal in terms of shape types and decorative repertoire.

In conclusion, these results allow for further considerations about the common idea of mobility of men versus mobility of goods, that is the starting issue of this research. The data achieved demonstrate how the traditional assumptions about the cultural relation between Sicily and Malta in the Middle Bronze Age has to be fully revised and how crucial has become the support of archaeometry for the proper operation of archaeology.

In this perspective the theory of a long term Maltese colonial outpost at Ognina, between Early and Middle Bronze Age, formulated by L. Bernabò Brea (1966), that conditioned the study of other later scholars who inferred similar phenomena for other Sicilian sites producing Maltese type pottery, has to be fully revised. It is obvious that the development of this new archaeometric approach to the study of pottery apparently seeming foreign in prehistoric Sicily, has the potential of bridging some gaps in the previous research and of making scholars to understand what truly happened instead of what they think it happened in terms of interchanges, in this case, between groups of Sicily and Malta.

The current project is far from its end. The database of petrographic and chemical data about Borġ in-Nadur pottery of Sicily is currently under update and the first step in the agenda will be sampling the Thapsos pottery found at Malta in order to verify a feedback in terms of natives moving from Sicily to Malta.

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